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Assessment of Biota and Habitat in Tributaries of Big Creek and the South Fork Salmon River, Payette National Forest

Prepared For:

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McCall, Idaho

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David Burns
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Dear Dr. Burns,

Enclosed you will find a copy of the final report summarizing the data from the 1998 field season entitled; Assessment of Biota and Habitat in Tributaries of Big Creek and the South Fork Salmon River, Payette National Forest. If you have any questions or comments please contact either Kate Bowman at (208) 236-2139, or G. W. Minshall at (208) 236-2236.

Sincerely,

Kathryn Bowman

Kathryn Bowman

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SUMMARY

This report presents the results of our research conducted for the Payette National Forest during 1998. As in previous years, our research was conducted on two groups of streams: (1) tributaries to Big Creek inside the Frank Church Wilderness Area, and (2) tributaries to the South Fork of the Salmon River immediately west of the wilderness area. These streams have been influenced by various wildfires since 1988. The effect of wildfires on stream ecosystems has been the focus of our research over the past several years; however our efforts also are directed towards defining the range of natural variation in wilderness streams (see Royer et al. 1995, Royer and Minshall 1996).

In general, no substantial changes in water chemistry of the streams have been observed in the tributaries to Big Creek or the South Fork Salmon River during the sample period. Similarly, measurements of physical habitat characteristics have not displayed any consistent pattern over the course of the study. It appears that the Golden Fire has not, to date, been a major influence on the physical and chemical habitat of Cliff, Cougar, or Goat Creeks. The Rush Point Fire also appears to have not significantly affected the physical or chemical habitat of Pioneer or Rush Creek. Similarly, in the South Fork Salmon watershed, the Chicken Fire has not created unstable habitat conditions in Fritser Creek. Overall, the physical and chemical habitat of the study streams has not been altered by the Golden Fire, Rush Point Fire or the Chicken Fire.

Corresponding with the relative stability of the stream's physical and chemical habitat, the biotic components of the study also have not displayed any consistent patterns for evidence of fire on these streams. Periphyton has not shown any substantial changes in either chlorophyll-a or biomass/m^2. Because the habitat has not been altered substantially, it is not surprising that the benthic macroinvertebrate community metrics have also remained fairly consistent during the ten year study period. Macroinvertebrate density, biomass, species richness and Simpson's Index have not been significantly affected by the Golden, Rush Point or Chicken Fires.

An additional research goal during 1998 was to monitor effects of salvage logging on

Big Flat Creek, which is located along the lower portion of the South Fork Salmon River, and to compare it with data collected in 1996 prior to logging. Although no physical habitat data were collected in 1996, Big Flat Creek was visibly disturbed and macroinvertebrate comparisons show a significant loss in taxa between the two years.

The collection of baseline data and the description of natural variation in ecological conditions is a major goal of this research. In this regard, macroinvertebrate density and taxa richness appear to be useful metrics for describing the natural variation in the structure of macroinvertebrate communities in these streams. The reference streams (Pioneer, Rush, and Cave) have shown variation in these community metrics between years, but the long term mean has remained consistent. Even streams in moderately disturbed watershed conditions apparently have remained relatively stable. The severity of future disturbances may be determined by examining changes in the density and/or number of taxa, relative to the long-term mean in a given stream.

INTRODUCTION

Our primary research goal during 1998 was to continue monitoring tributaries to Big Creek and the South Fork of the Salmon River (S.F. Salmon) that we had examined in previous years. These streams have been examined in relation to the role of wildfire in structuring benthic habitat and invertebrate communities in the Payette National Forest and in defining the range of natural variation in burned and unburned reference streams (Royer and Minshall 1996, Royer et al. 1995). The studies in the Big Creek catchment were designed to examine the influence of the 1988 Golden Fire and Rush Point Fire, while those in the S.F. Salmon catchment examined the 1994 Chicken Fire. To date, the effects of these wildfires on stream invertebrate communities have been inconclusive, with no clear and discernable patterns emerging over several years of study. However, these streams are important for wilderness monitoring because they and their unburned reference streams represent a range of stream types that serve to define the natural variability found in relatively pristine stream ecosystems.

For all streams examined, the results provide baseline habitat and macroinvertebrate data against which the effects of future disturbances (natural or anthropogenic) can be measured. This was the goal of our work on Tailholt and Circle End Creeks, where an experimental timber harvest was planned for Tailholt (USFS 1995). However, the timber harvest, originally scheduled for autumn 1996, was cancelled, thereby providing another year of baseline data on that system. Circle End and Tailholt Creeks also provide reference streams for Fritser Creek. An additional component was added to the study in 1996: examining the effects of salvage logging on Big Flat Creek along the lower portion of the S.F. Salmon. Smith Creek, adjacent to the timber sale, was also sampled and serves as a reference for Big Flat Creek. These streams were sampled just prior to the onset of the salvage logging, thereby providing a "pre-logging" data set for these sites. In 1996 the extremely small size of Big Flat Creek precluded standard channel surveys and only qualitative macroinvertebrate samples were collected. No samples were collected in 1997 because of road closings due to the 1997 spring runoff event. Smith Creek and Big Flat Creek were sampled in 1998 and taxa richness, determined in previous studies to be a good indicator of disturbance, indicates that future sampling of Smith and Big Flat Creeks will provide beneficial information on disturbance by salvage logging.

STUDY SITE DESCRIPTIONS

The study streams were located within the Payette National Forest in central Idaho either (1) along Big Creek in the Frank Church 'River of No Return' Wilderness Area or (2) along the South Fork of the Salmon River just outside the wilderness area (Table 1). In both catchments, the streams flow through steep valleys with forested slopes of primarily Douglas-Fir and Ponderosa Pine, also present are extensive bare or sparsely vegetated areas. Open areas of grass and sagebrush are common on the drier slopes in both catchments. The majority of the annual precipitation occurs as snow, resulting in peak flows from late spring through mid-summer. The streams generally remain at baseflow conditions from late summer through autumn.

Study streams in the Big Creek catchment were influenced, to varying degrees, by either the Golden Fire of 1988 or the Rush Point Fire of 1991. The upper portions of the Cliff

Table 1. Location of the 1998 study streams in the Big Creek and South Fork of the Salmon River catchments.

Stream	Elevation	Longitude	Latitude	Township	Range
Big Creek Catchment					
Rush Creek	1170	114° 51' W	45° 07' N	T20N	R13E
Pioneer Creek	1165	114° 51' W	45° 06' N	T20N	R13E
Cave Creek	1220	114° 57' W	45° 08' N	T20N	R13E
Cliff Creek	1195	114° 51' W	45° 07' N	T20N	R13E
Goat Creek	1125	114° 48' W	45° 07' N	T20N	R13E
Cougar Creek	1095	114° 49' W	45° 07' N	T20N	R13E
Big Creek	1150	114° 50' W	45° 06' N	T20N	R13E
South Fork Salmon Catchment					
Circle End Creek	1110	115° 39' W	45° 02' N	T20N	R13E
Tailholt Creek	1110	115° 39' W	45° 02' N	T20N	R13E
Fritser Creek	1036	115° 38' W	45° 05' N	T20N	R13E
Smith Creek	914	115° 31' W	45° 14' N	T20N	R13E
Big Flat Creek	914	115° 33' W	45° 13' N	T20N	R13E

and Cougar were affected by the Golden Fire; Goat Creek was not burned by the wildfire, but rather by an intentional "back-burn". Cave Creek serves as a reference for these sites. All of the above streams have a southern aspect. The upper portion of the Rush and Pioneer Creek catchments were minimally influenced by the Rush Point Fire and have northern aspects. Thus they provide a comparison with the south-facing streams listed above.

In the South Fork Salmon River catchment, Fritser Creek was moderately burned during the Chicken Fire of 1994. Tailholt and Circle End were not affected by the Chicken Fire. Although Tailholt and Circle End were examined beginning in 1994, Fritser Creek was not studied until 1995. All of the S.F. Salmon tributaries we examined had a southeastern aspect. The streams in the salvage logging study were burned by the Chicken Fire in 1994 and subsequently logged in 1996. The reference site, Smith Creek, was considerably larger than any of the logged streams, but provided the only accessible reference stream in the immediate area due to numerous road closures related to the logging activities. All sites were affected in varying degrees by the high spring runoff event in 1997 and due to the numerous road closures, were not examined again until 1998.

METHODS

Physical, chemical, and biological parameters were measured in all streams. Measurements of the physical habitat of the channel and water constituents provide important information about current stream conditions and are especially useful in year-to-year comparisons. Biological monitoring gives an indication of past as well as current ecological conditions. The Big Creek tributaries were sampled July 20 to 23 and the South Fork Salmon tributaries were sampled July 27 to 29, 1998. Field methods used for the various portions of this study are summarized in Table 2. The methods were consistent with methods used in our previous studies of wildfire and wilderness streams. These are relatively routine in stream ecology and are described in detail in standard reference sources (Weber 1973, Greeson et al. 1977, Lind 1979, Stednik 1991, Merritt and Cummins 1996, APHA 1992, Platts et al. 1983, Davis et al. *in press*). Mean substratum size, water depths, and embeddedness were determined

Table 2. Summary of variables, sampling methods, and analytical procedures used in the study.

Variable	Type*	Sampling Method	Analytical Method
A. Physical			
Substratum Size	R	Measure x-axis of 100 randomly selected substrata	Calculate mean substratum size
Substratum Embed-dedness	R	Visual estimation of 100 randomly selected substrata	Calculate mean substratum embeddedness
Stream Width	T	Measure bankfull width using a nylon meter tape	Calculate mean stream width
Stream Depth	R	Measure water depth at the 100 randomly chosen substrata	Calculate mean water depth
Discharge	T	Velocity/depth profile Velocity measured with an Ott meter	Q=A x v; where Q=discharge, A=cross-sectional area, and V=mean velocity
B. Chemical			
Conductivity	P	Field measurement	Temperature comp-ensated meter (Orion model 126)
Alkalinity	P	Water sample	Methyl-purple titration
Hardness	P	Water sample	EDTA titration
C. Biological			
Invertebrates	R	Collect 5 samples using a Surber sampler	Remove invertebrates, identify, enumerate, and analyze
Benthic Organic Matter	R	Recover from Surber samples	Determine AFDM
Periphyton	R	Collect 5 samples from individual substrata	Methanol extraction and spectrophotometric analysis

* P=point measure; T=transect across stream; R=random throughout a defined reach.

at 100 random locations along a substantial (ca. 200 meter) reach of stream.

Procedures for sample analysis are described briefly in Table 2. Density, biomass, taxa richness, and Simpson's Index were determined for the macroinvertebrate communities for all sites and years. In addition, the 15 most abundant taxa at each stream were determined and used to evaluate year-to-year stability of the communities.

RESULTS

Big Creek Tributaries

In general, no substantial changes in water chemistry of the streams have been observed in the Big Creek tributaries over the study period (Table 3). In 1998 hardness increased from 1997 in Cave, Cliff, Goat and Cougar Creeks and were the highest values in the ten years of study. Alkalinity values, however, remained consistent with 1997 values and the ten year average. The unlikely difference between hardness and alkalinity suggests that the particularly high hardness values may be attributed to technician error. The measurements of physical habitat in the streams also have not varied in any consistent manner over the course of the study (Table 4). Goat and Cougar Creeks have increased in bankfull width and substrate embeddedness has decreased substantially over the last three years, from approximately 50% to less than 10% embeddedness (Table 4). A decrease in mean substrate embeddedness also was measured in Rush and Pioneer Creeks, but not significantly. Mean substrate size did not change significantly in any of the streams over the same time period. An increase in substrate size was measured in Goat Creek between 1997 and 1998, but is within the ten year range.

Mean values of periphyton chlorophyll-a remained the same or increased slightly in all streams between 1997 and 1998 (Fig. 1). Periphyton chlorophyll-a values were low in both 1997 and 1998 compared to the 10 year average for all streams except for Cougar, which was more variable than the other sites (Fig. 1). Periphyton ash-free dry mass (AFDM) values were not significantly different among the 1998 sites (Fig. 3) due to the high within site variability, but increased at all sites from 1997 to 1998. Goat had the highest mean AFDM in the 1998. Pioneer

Table 3. Discharge and chemical measures for the study streams in the Big Creek catchment.

Stream	Year	Discharge (m3/s)	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)	Conductance (uS/cm @ 20C)	pH
Rush	1988	1.61	36	30	110	7.8
	1991				103	8.2
	1992	1.10	46	46	95	8.4
	1993	0.31				7.9
	1994	1.56			77	
	1995	1.75	32	57	76	8.2
	1996	1.59	36	80	99	8.5
	1997	1.94	30	65	85	7.4
	1998	2.17	32	48		
Pioneer	1990	0.16	62	86	88	8.1
	1991	0.01			125	8.0
	1993	0.02	26	48	72	
	1994	0.17			113	
	1995	0.21	42	81	135	7.9
	1996	0.11	40	70	119	7.7
	1997	0.16	36	77	108	8.1
	1998	0.23	41	52		
Cave	1990	0.31	24	44	39	7.9
	1993	0.08	19	24	55	
	1994	0.21				
	1995	0.17	20	40	48	8.1
	1996	0.22	44	48	66	7.8
	1997	0.29	20	36	64	7.9
	1998	0.34	39	73		
Cliff	1988	0.04			67	8.4
	1990	0.32	35	66	61	8.2
	1991	0.18	77	71	73	8.2
	1992	0.08	48	49	99	8.0
	1993	0.09	26	44	77	7.7
	1994	0.10			79	
	1995	0.15	34	53	93	8.2
	1996	0.14	32	42	105	7.3
	1997	0.17	24	57	86	8
	1998	0.19	32	103		
Goat	1990	0.01	86	110	139	8.1
	1991	0.09	49	51	153	8.4
	1992	0.01	80	76	151	8.2
	1993	0.01	41	68	116	8.1
	1994	0.01			148	
	1995	0.01	56	93	140	8.1
	1996	0.04	50	68	157	8
	1997	0.03	48	89		
	1998	0.05	43	156		
Cougar	1990	0.11	46	71	70	8.5
	1991	0.10	36	32	93	7.4
	1992	0.01	59	60	113	8.2
	1993	0.02	33	48	94	7.7
	1994	0.08				
	1995	0.10	48	85	107	8.2
	1996	0.15	52	80	158	8.2
	1997	0.13	44	89		
	1998	0.15	38	107		

Table 4. Habitat heterogeneity measures for study streams in the Big Creek catchment. SD = standard deviation, CV = coefficient of variation.

		Substrate Size (cm)			Substrate Embeddedness (%)			Bankfull Width (m)		Baseflow Depth (cm)	
Stream	Year	mean (n=100)	SD	CV	mean (n=100)	SD	CV	mean (n=5)	SD	mean (n=100)	SD
Rush	1988	14.6	14.0	0.96				15.1		35.0	10.0
	1992	13.3	9.2	0.69	18.8	26.7	0.96	12.0		21.0	10.0
	1993	21.3	14.8	0.69	35.0	28.9	0.51	13.4	1.5	26.2	7.3
	1994	13.9	13.2	0.95	39.3	34.0	0.46	6.3	4.8	26.2	7.9
	1995	22.6	16.7	0.74	25.0	26.2	1.05	11.8	0.6	35.0	10.3
	1996	21.0	20.0	0.95	30.0	36.0	1.20	13.9	2.4	25.4	15.0
	1997	18.0	17.0	0.94	38.0	28.0	0.74	12.1	1.2	27.0	14.0
	1998	14.1	11.1	0.78	22.5	28.2	1.25	13.8	1.8	33.2	12.5
Pioneer	1990	16.7	14.0	0.84	12.5	23.9	1.44	3.4		16.0	4.5
	1993	19.5	18.7	0.96	33.8	28.8	0.53	2.9	0.9	15.3	7.7
	1994	13.9	15.2	1.09	34.3	33.7	0.53	1.7	4.2	18.0	7.9
	1995	15.2	17.4	1.14	45.3	36.3	0.80	3.0	0.6	17.5	10.1
	1996	17.0	20.0	1.18	44.0	40.0	0.91	2.7	0.5	14.7	9.3
	1997	18.0	17.0	0.94	20.0	28.0	1.40	2.6	0.6	17.0	9.0
	1998	16.0	17.1	1.07	18.3	25.2	1.38	2.9	0.4	17.8	8.9
Cave	1990	18.8	12.2	0.65				6.1		15.0	6.0
	1993	18.2	17.0	0.93	59.8	29.8	0.30	5.4	0.5	15.3	8.1
	1994	18.3	15.9	0.87	45.0	33.9	0.40	4.1	8.1	15.6	9.5
	1995	15.1	18.7	1.24	56.5	33.1	0.59	5.2	1.2	18.8	7.9
	1996	16.0	11.0	0.69	14.0	21.0	1.50	5.0	0.8	15.7	9.7
	1997	15.0	11.0	0.73	23.0	26.0	1.13	5.1	1.0	20.0	11.0
	1998	18.6	29.4	1.58	31.3	32.2	1.03	5.3	1.1	21.6	10.5
Cliff	1988	16.2	10.2	0.63				4.8		13.6	7.2
	1990	25.3	17.7	0.70				3.5		20.0	4.0
	1991	22.5	20.3	0.90				3.8		20.0	8.0
	1992	26.8	26.8	1.00				5.5		20.0	14.0
	1993	21.5	16.8	0.78	41.8	31.6	0.43	3.2	0.7	16.4	8.3
	1994	19.5	16.3	0.84	40.9	30.8	0.44	2.0	6.4	20.9	10.2
	1995	21.5	24.4	1.13	66.0	73.4	1.11	3.5	0.7	22.1	10.7
	1996	21.0	27.0	1.29	41.0	39.0	0.95	4.2	1.5	11.1	8.1
	1997	20.0	15.0	0.75	19.0	23.0	1.21	3.0	0.3	18.0	10.0
	1998	21.7	21.4	0.98	25.3	26.3	1.04	3.0	1.0	22.9	11.7
Goat	1990	9.7	16.5	1.70				0.9		10.0	2.0
	1991	10.9	16.4	1.50				0.9		10.0	3.0
	1992	13.1	17.0	1.30				0.8		10.0	7.0
	1993	17.5	16.6	0.95	43.8	35.4	0.41	1.1	0.3	12.0	4.1
	1994	11.7	16.1	1.38	68.5	31.1	0.26	0.9	0.2	10.4	4.4
	1995	12.0	14.0	1.16	65.3	34.5	0.53	1.2	0.3	10.8	5.7
	1996	24.0	27.0	1.13	55.0	37.0	0.67	1.3	0.2	5.9	4.1
	1997	7.0	10.0	1.43	11.0	20.0	1.82	0.8	0.7	12.0	5.0
	1998	16.2	24.2	1.49	2.8	9.3	3.38	2.3	0.8	8.8	7.9
Cougar	1990	21.6	13.0	0.60				2.7		20.0	
	1991	22.6	27.1	1.20				3.1		20.0	6.0
	1992	13.0	14.3	1.10				2.6		20.0	20.0
	1993	21.1	20.9	0.99	42.5	30.5	0.42	2.5	0.9	16.3	8.1
	1994	15.5	11.9	0.77	50.3	33.8	0.36	1.6	0.7	18.8	10.3
	1995	19.2	17.1	0.89	47.5	31.5	0.66	2.5	0.6	20.3	11.3
	1996	20.0	24.0	1.20	46.0	39.0	0.85	2.8	0.5	12.7	8.0
	1997	18.0	14	0.78	18.0	23	1.28	2.7	0.7	18.0	10
	1998	19.5	21.5	1.1	7.0	15	2.15	3.8	0.6	18.4	12.6

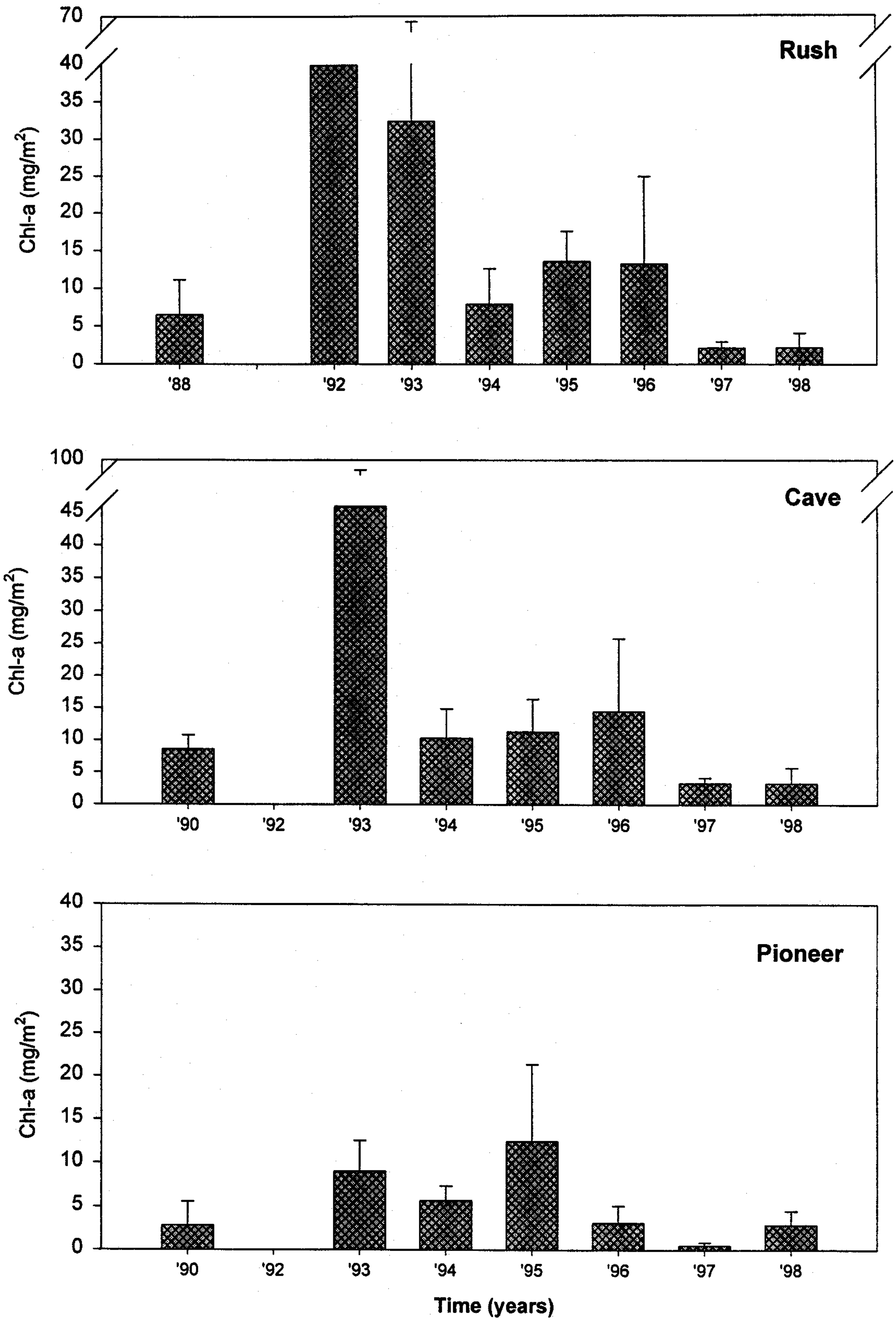
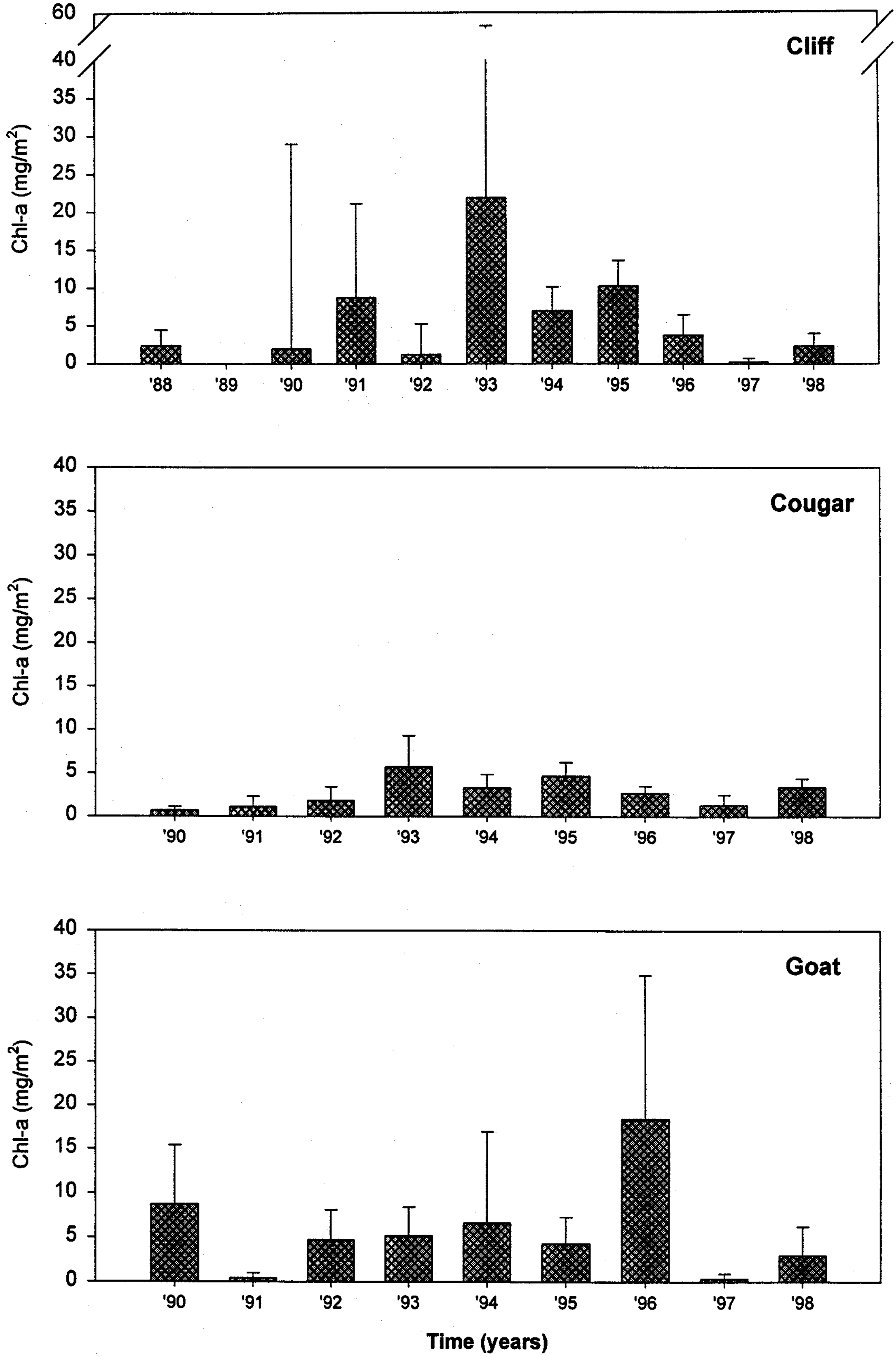


Figure 1. Mean values of periphyton chlorophyll *a* for the study streams. Error bars equal +1SD from the mean, n=5.



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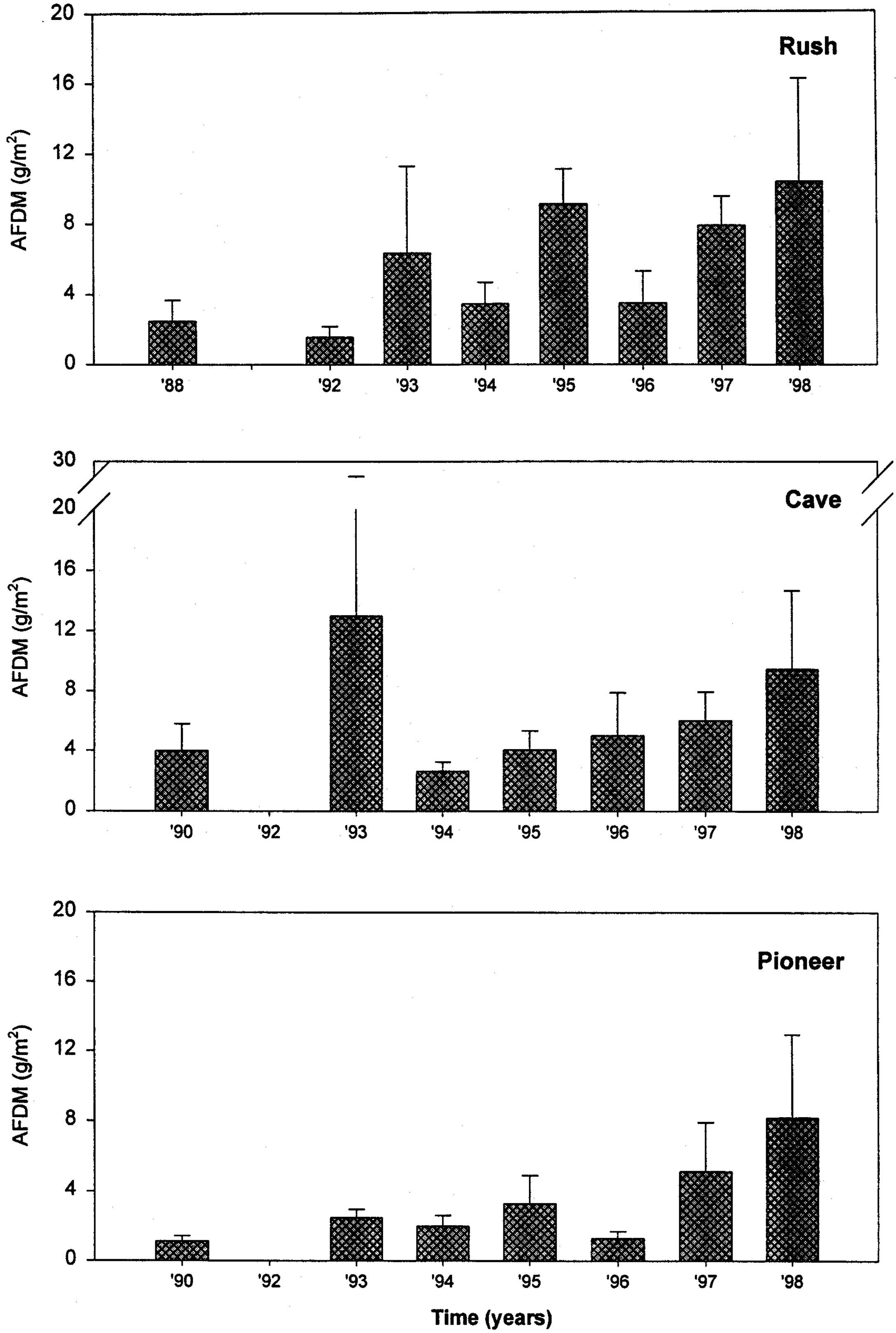
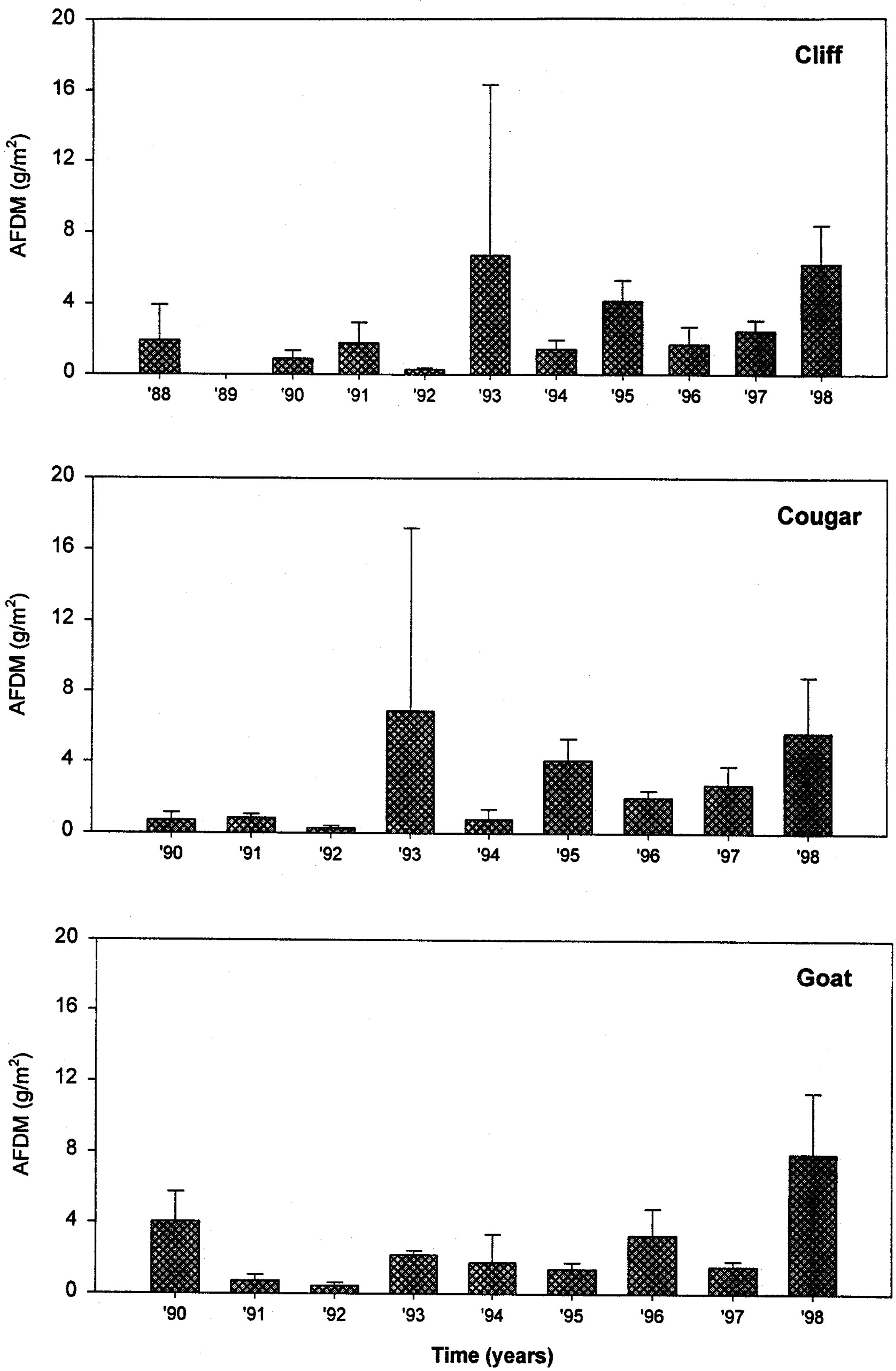


Figure 2. Mean values of periphyton ash-free dry mass (AFDM) for the study streams. Error bars equal +1SD from the mean, n=5.



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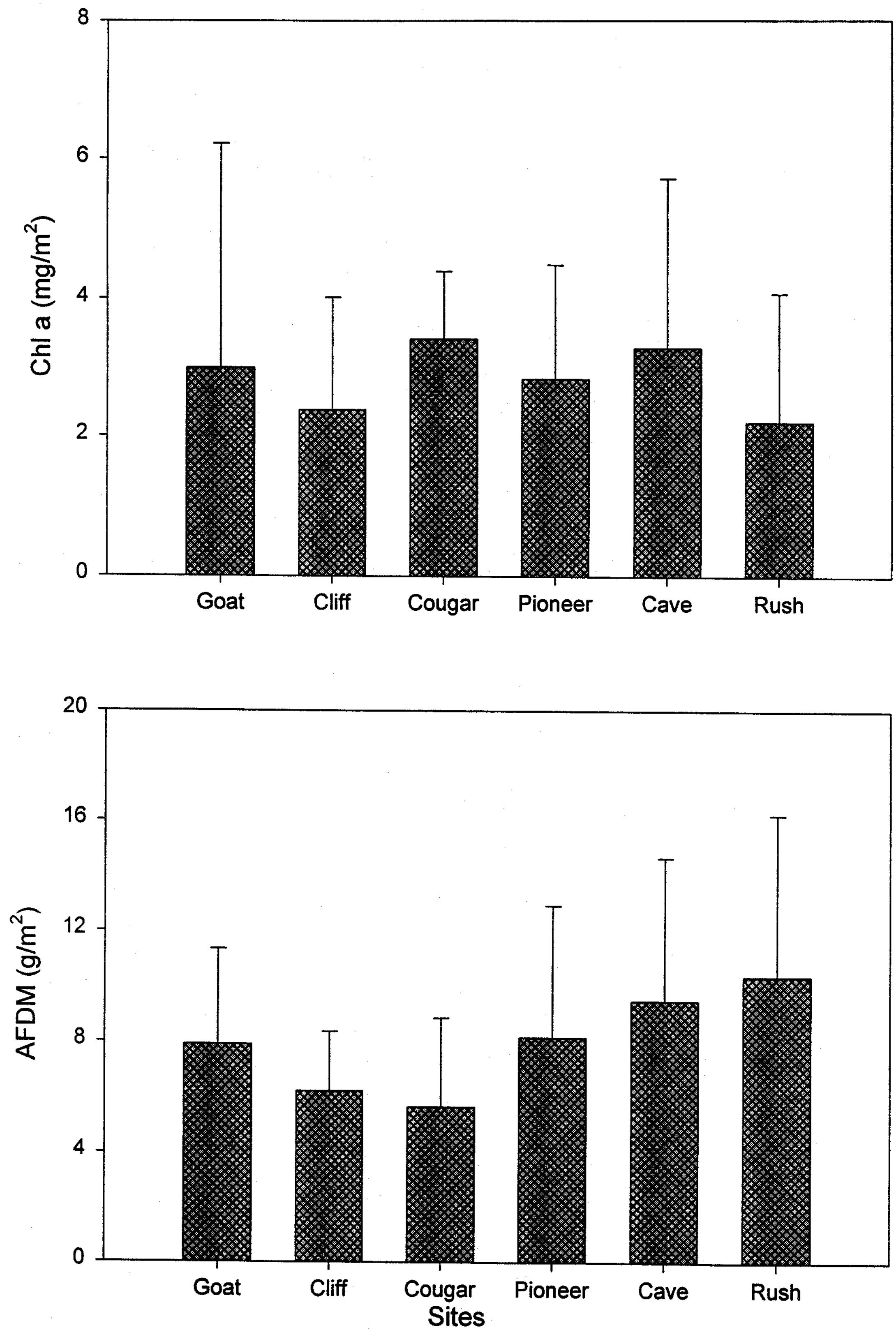


Figure 3. Periphyton chl a and AFDM from Big Creek and its tributaries in 1998.

and Rush also had relatively high AFDM means (Fig. 3). All values for periphyton AFDM were within the long term range. Mean benthic organic matter (BOM) associated with the Surber samples increased in most streams from 1997 except for Cave and Pioneer Creeks which decreased (Fig. 4). Mean BOM was highest in Goat Creek in 1998, but extremely variable (Fig. 5).

Mean aquatic macroinvertebrate density increased between 1997 and 1998 in all streams sampled. For the five years (1993-97), density in Rush ranged from approximately 5,000-13,000 individuals/m^2, this increased to 17,000 individuals/m^2 in 1998 (Fig. 6). Density in Pioneer Creek increased from approximately 3,000 individuals/m^2 to approximately 6,000 individuals/m^2 (Fig. 6) and density in Cave Creek was >19,500 individuals/m^2 in 1998, approximately four times as large as the values measured over the entire study period (Fig. 6). Macroinvertebrate density in Cliff Creek has fluctuated from approximately 3,000-5,000 individuals/m^2 since the outset of the study in 1988 but significantly increased to approximately 16,000 individuals/m^2 in 1998 (Fig. 6). Similarly, density in Cougar was higher than means during the previous five years (Fig. 6). Goat Creek has typically displayed the lowest invertebrate density of any of the streams sampled, however it more than doubled from 1997 to 1998, with a mean value of approximately 4,000 individuals/m^2 (Fig. 6).

Despite the increase in density in all streams sampled, mean macroinvertebrate biomass has remained fairly similar between 1997 and 1998 and consistent with long term trends (Fig. 7). Macroinvertebrate biomass remained unchanged from 1997 to 1998 in Rush and Cave Creeks and increased slightly in Pioneer Creek (Fig. 7). Biomass has remained relatively stable over the course of the study in Cliff Creek and remained fairly constant between 1997 and 1998 (Fig. 7). Goat and Cougar Creek mean macroinvertebrate biomass also remained consistent from 1997 to 1998 (Fig. 7).

Mean taxa richness increased in all of the study streams. Over the entire course of the study, taxa richness in Rush had remained stable with mean values of 25-30 taxa, but increased over the past two years to 47 taxa (Fig. 8). Pioneer mean taxa richness, 41 taxa, was the highest in the ten year sample period (Fig. 8). Mean taxa richness in Cave Creek was also the highest yearly mean to date, but did not increase as substantially as Pioneer and Rush Creeks (Fig. 8).

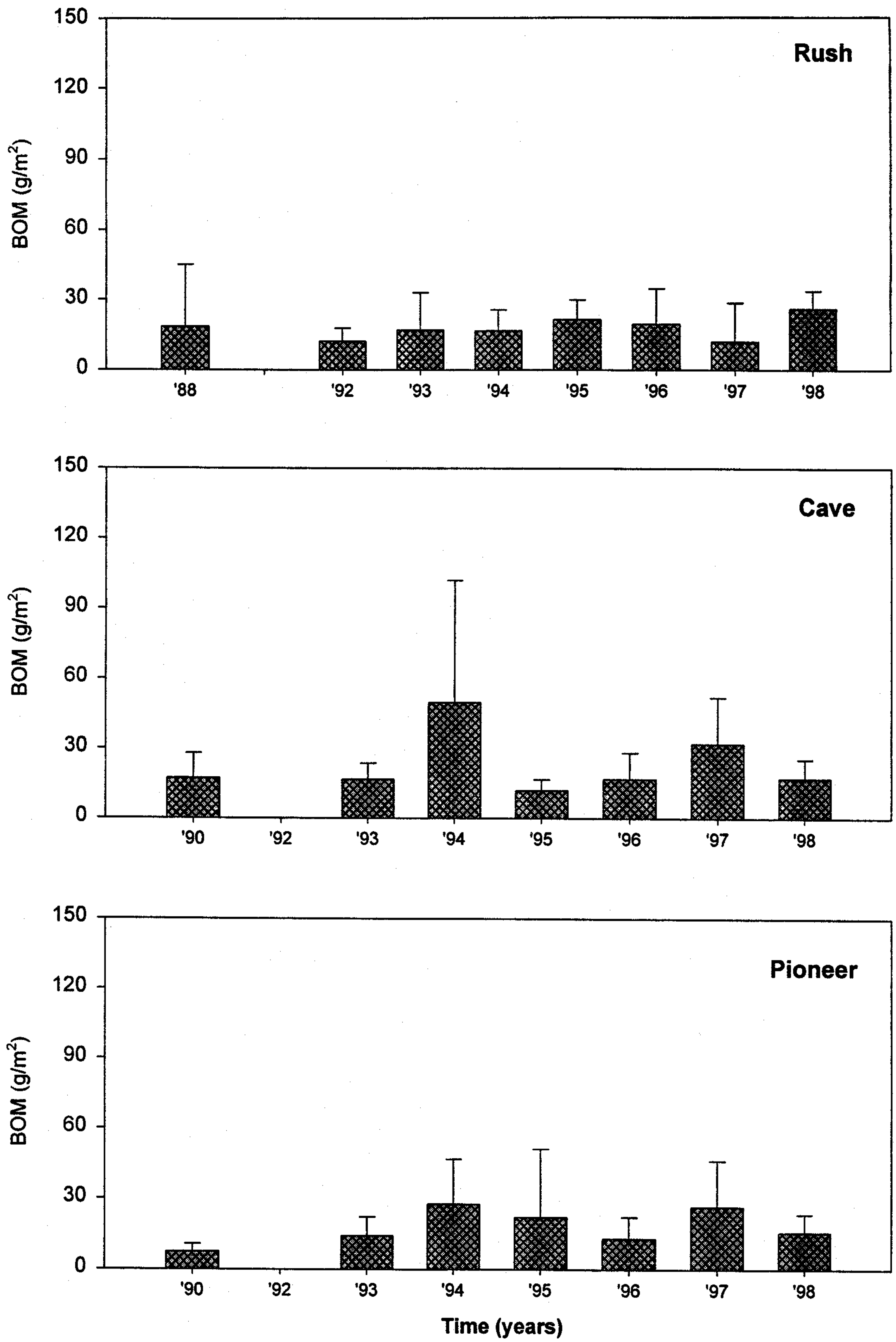
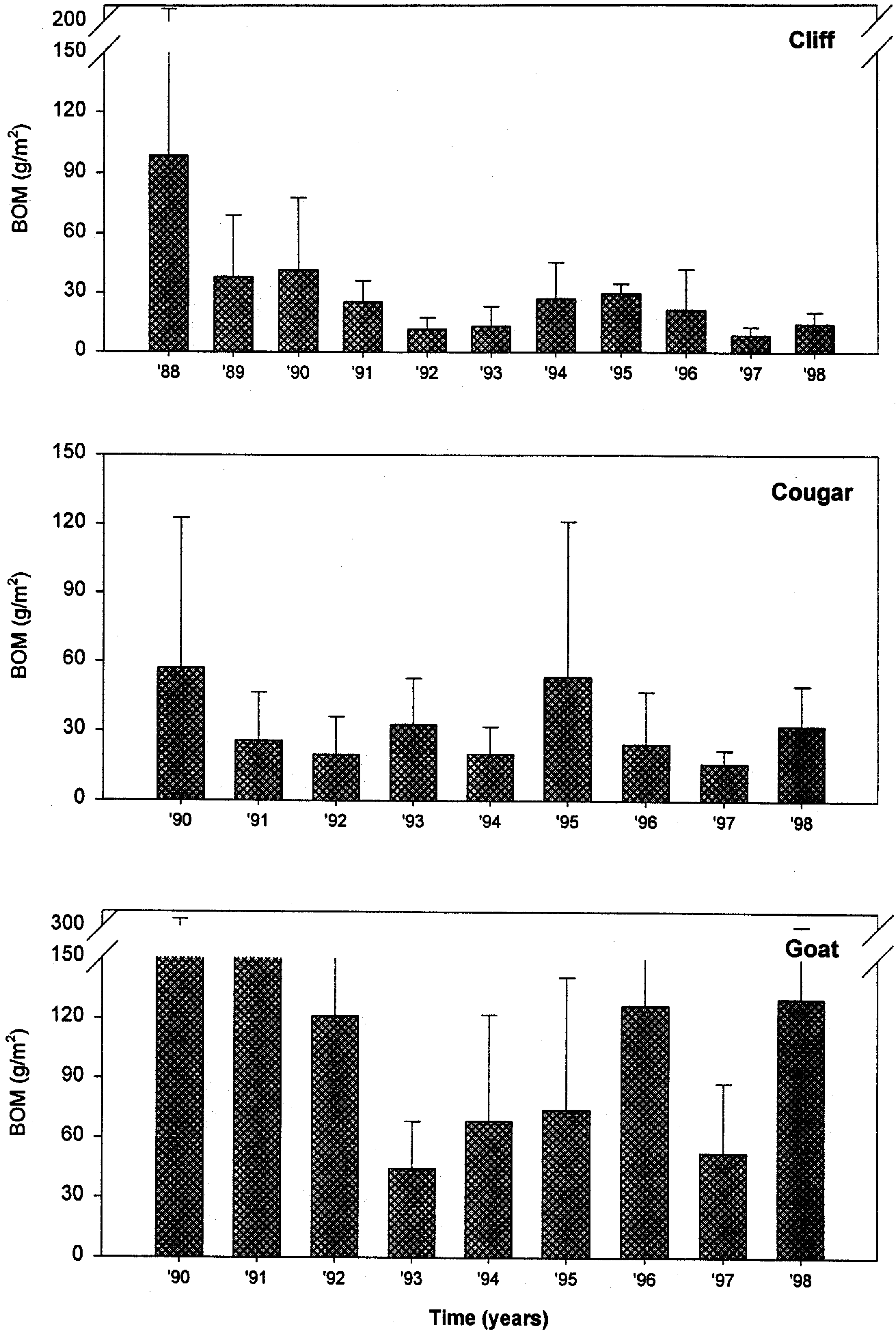


Figure 4. Mean dry mass of benthic organic matter (BOM). Error bars equal +1SD from the mean, n=5.



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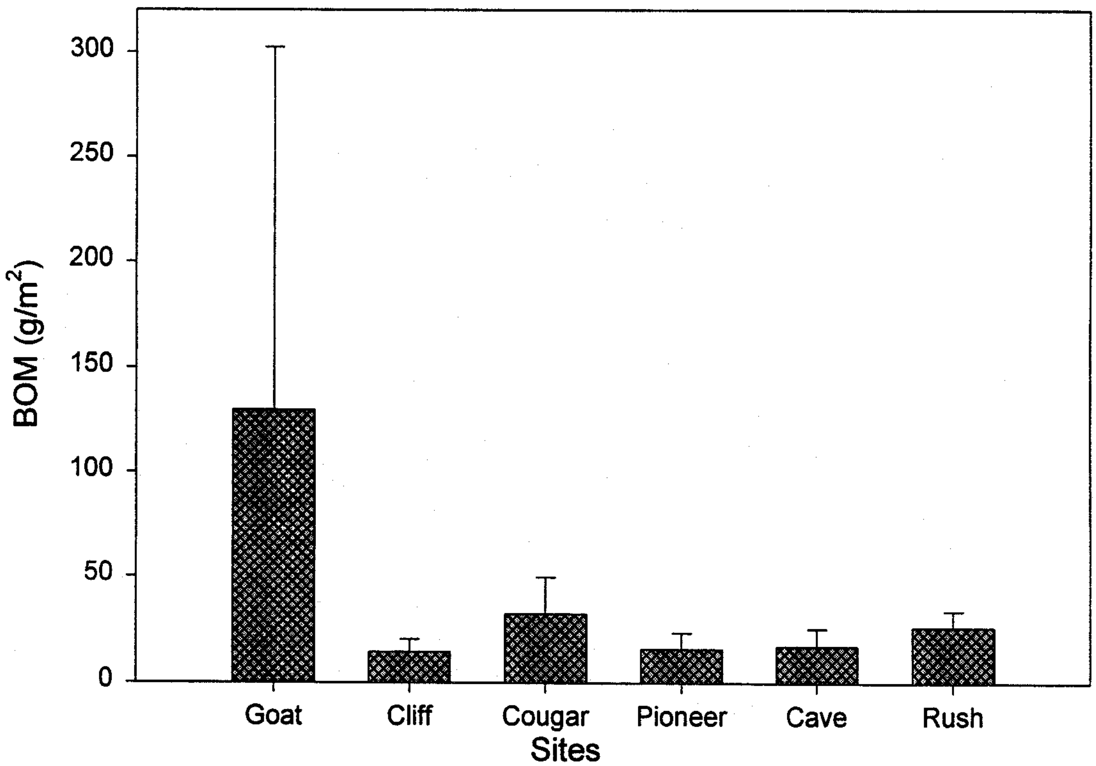


Figure 5. Mean benthic organic matter (BOM) dry mass for the Big Creek tributaries in 1998. Error bars equal +1SD from the mean, n=5.

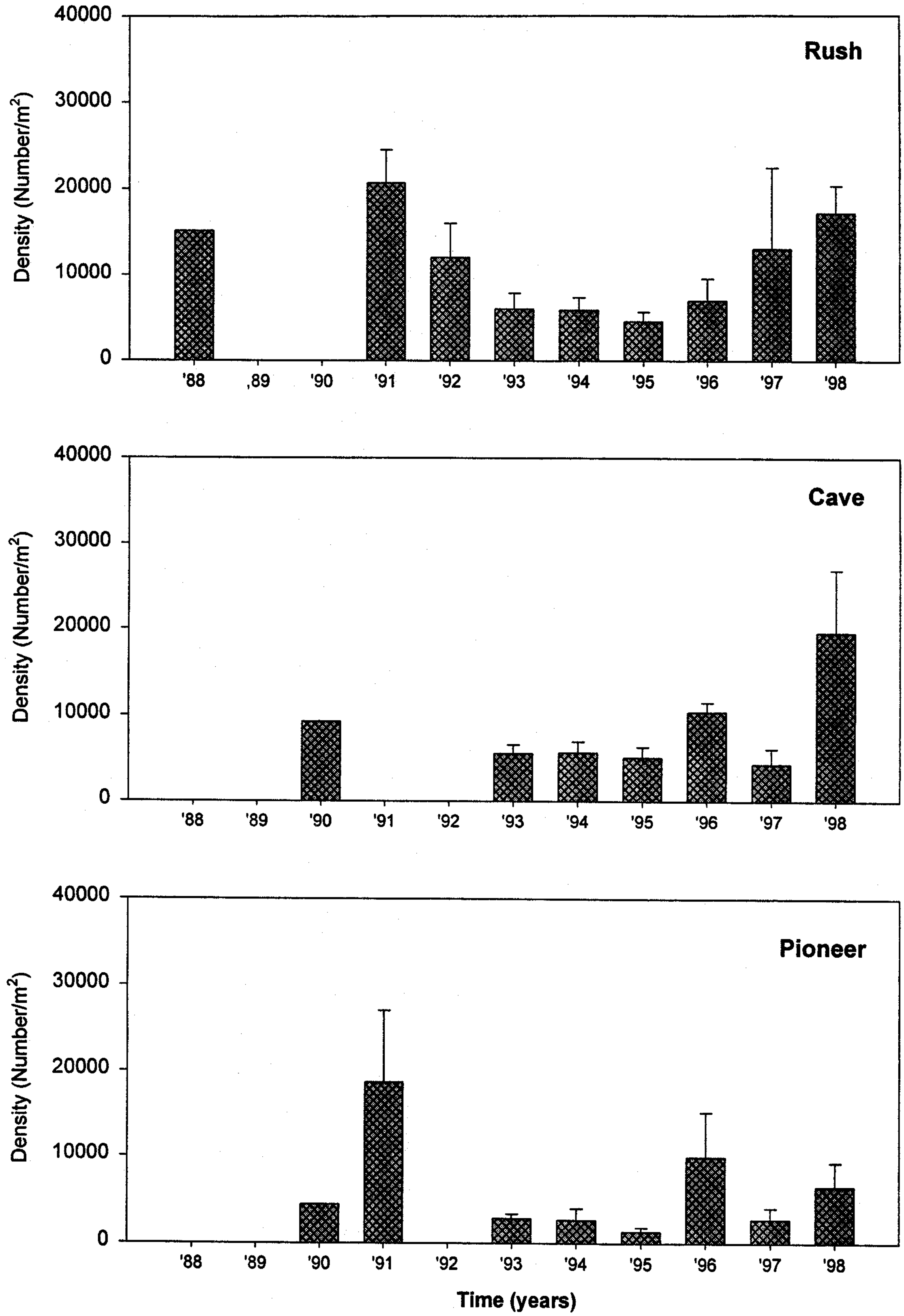
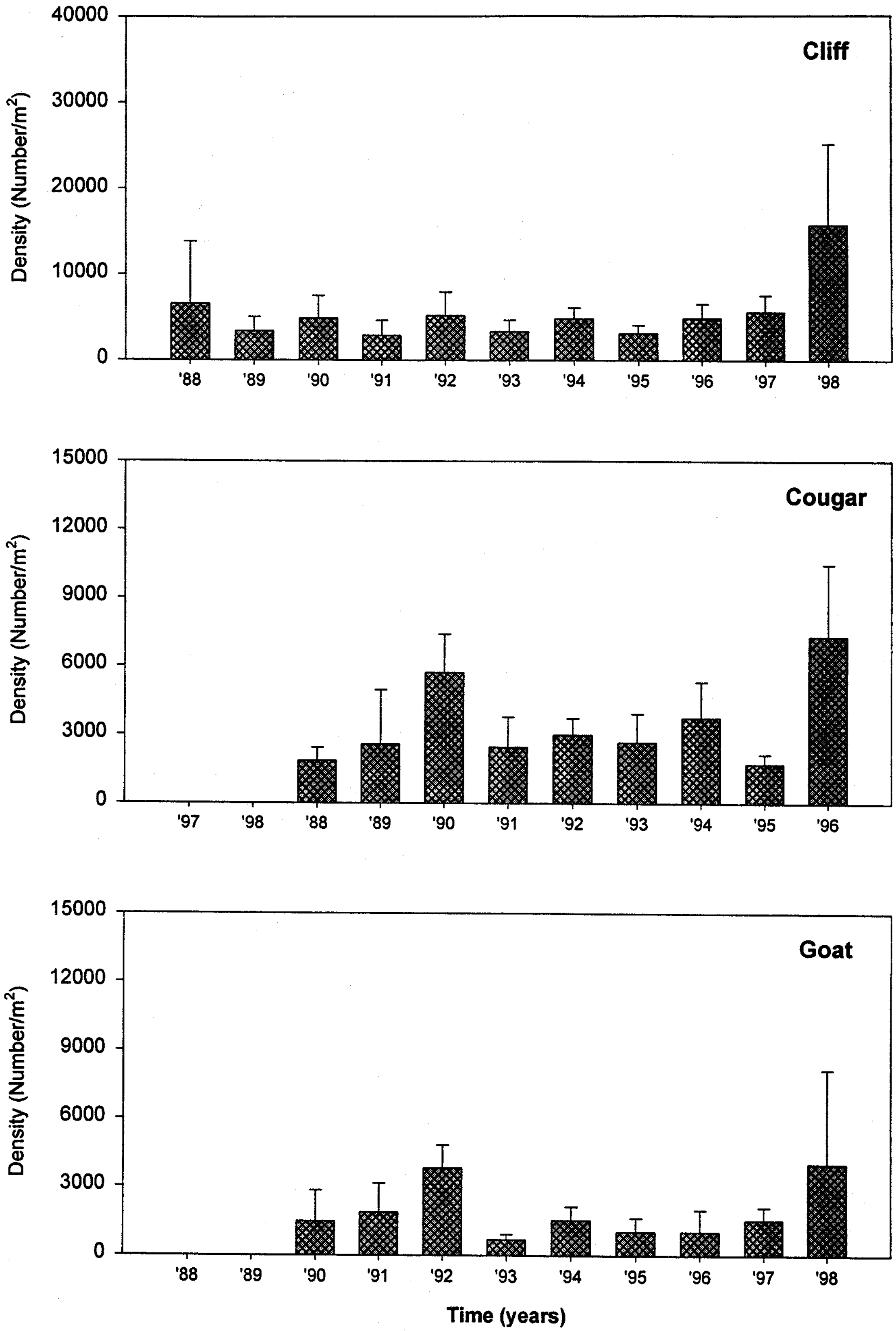


Figure 6. Mean macroinvertebrate density for each stream. Error bars equal +1SD from the mean, n=5.



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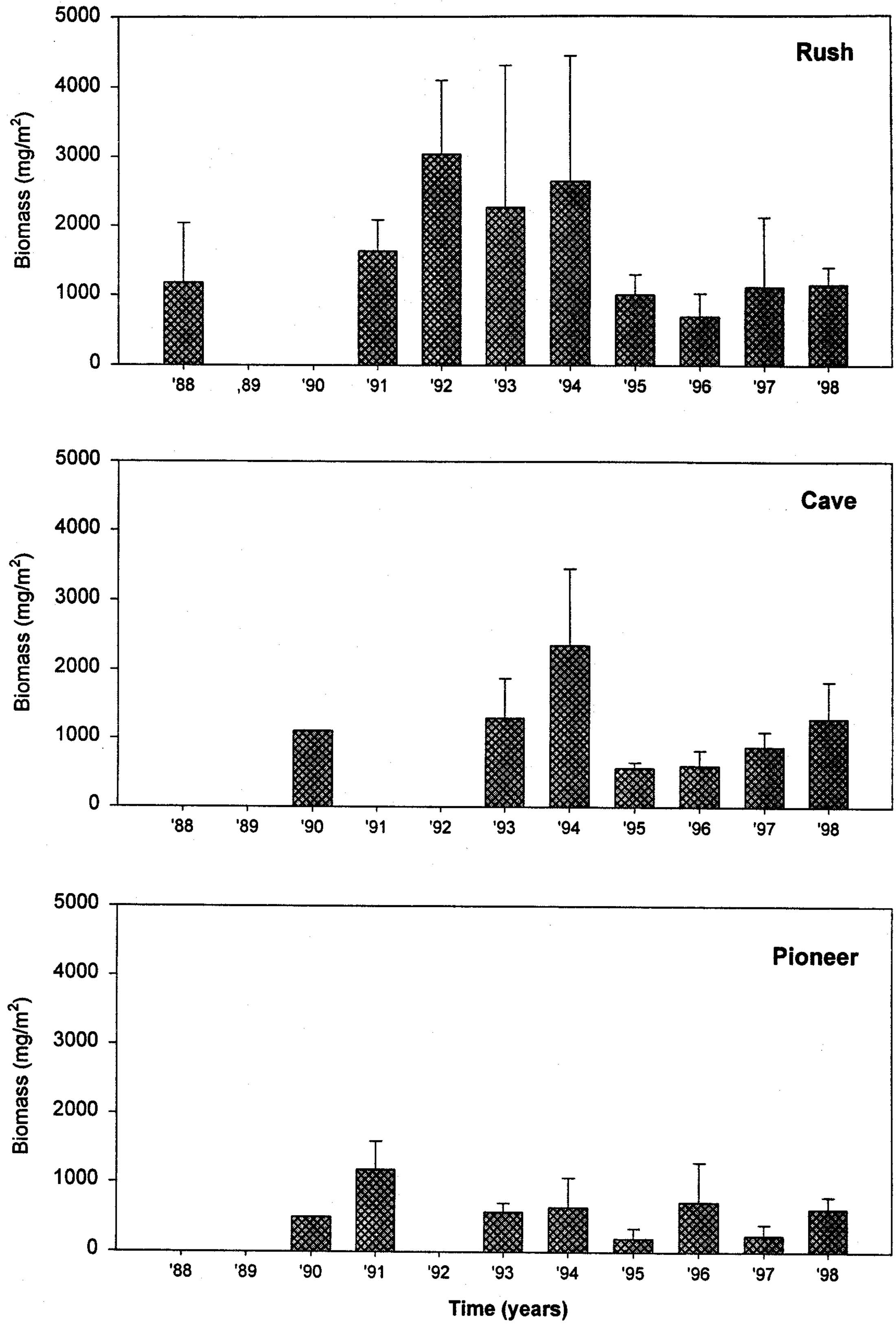
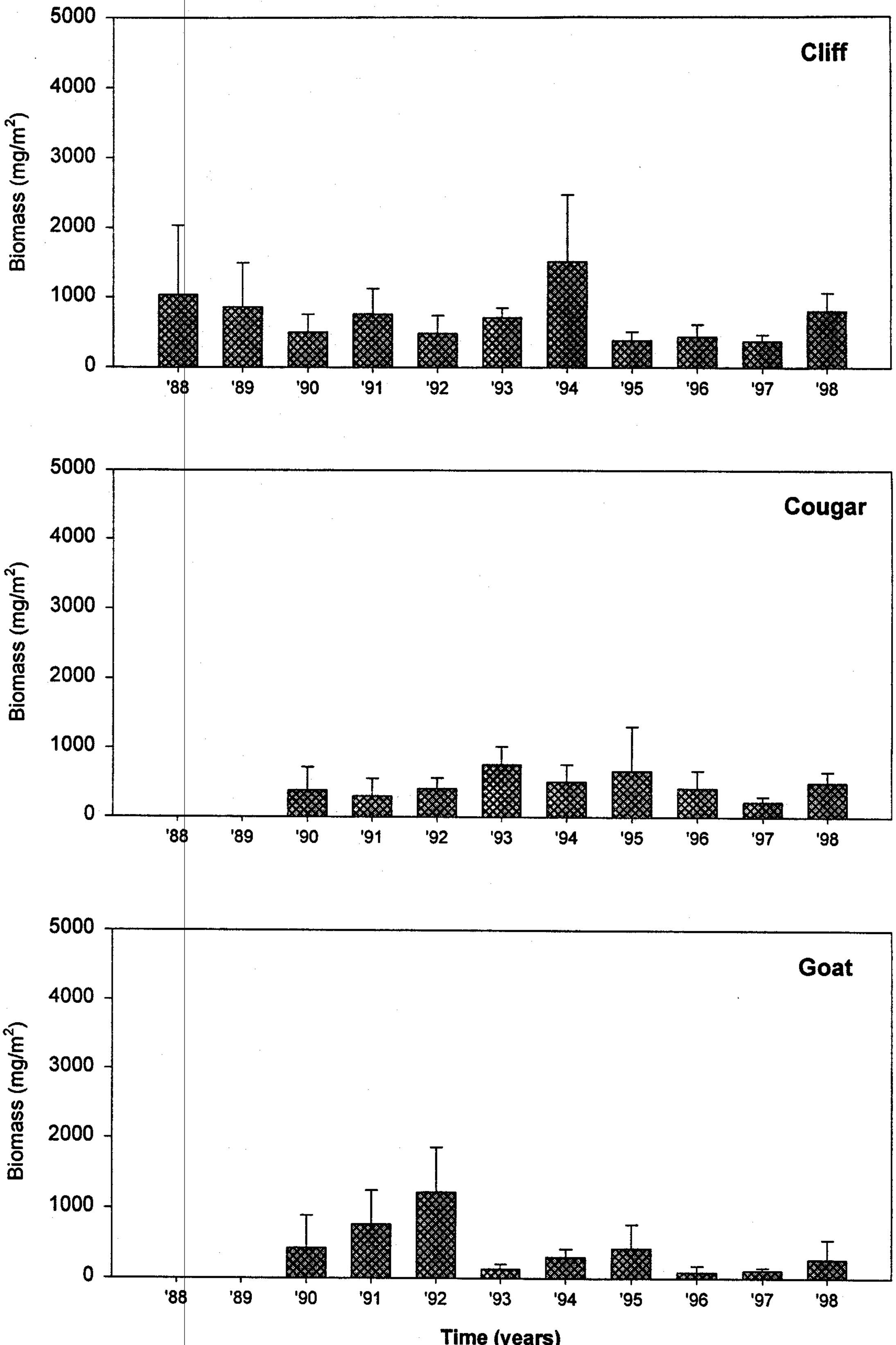


Figure 7. Mean macroinvertebrate biomass for each stream. Error bars equal +1SD from the mean, n=5.



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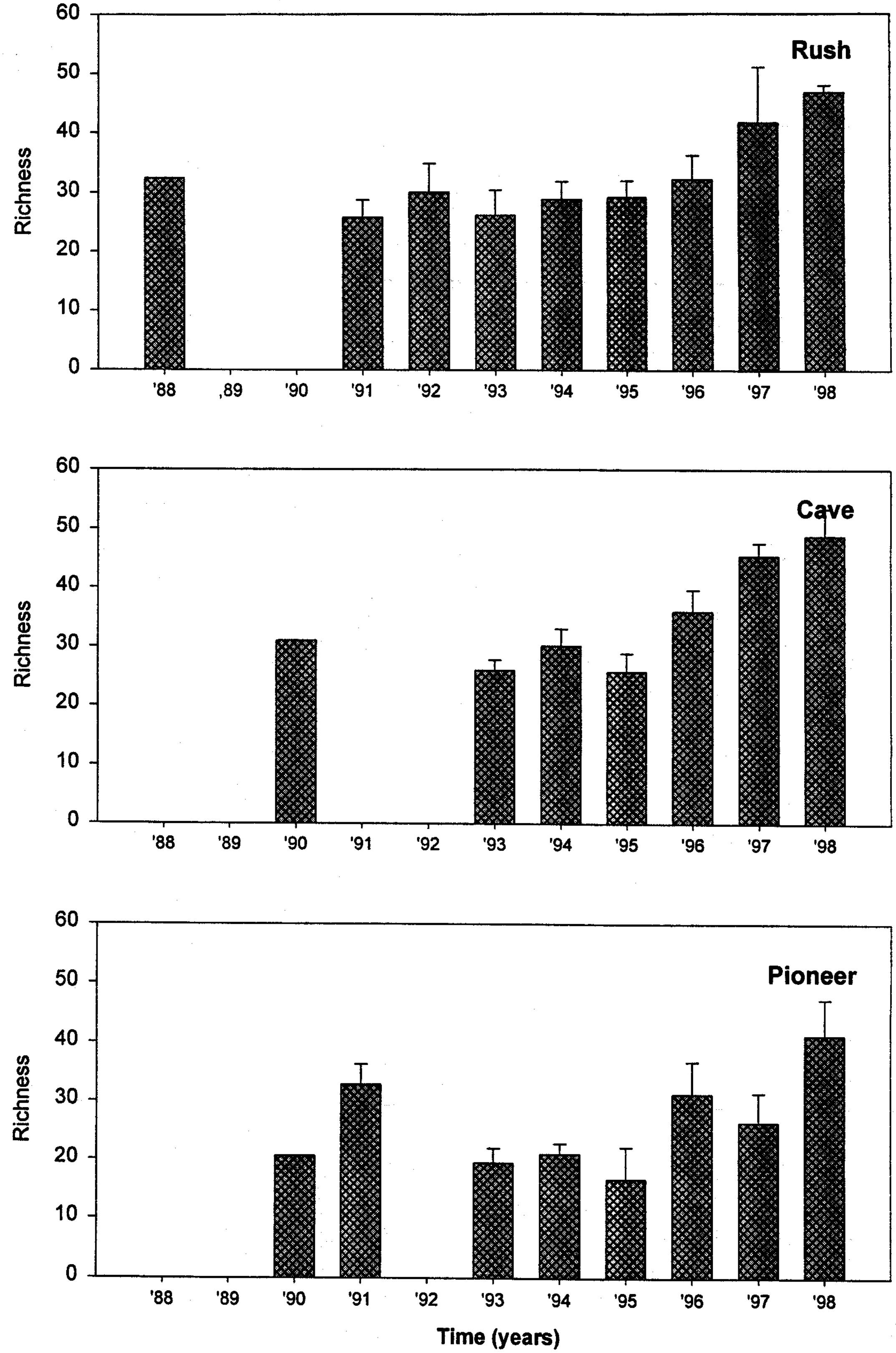

Figure 8. Mean macroinvertebrate richness for each stream. Error bars equal +1SD from the mean, n=5.

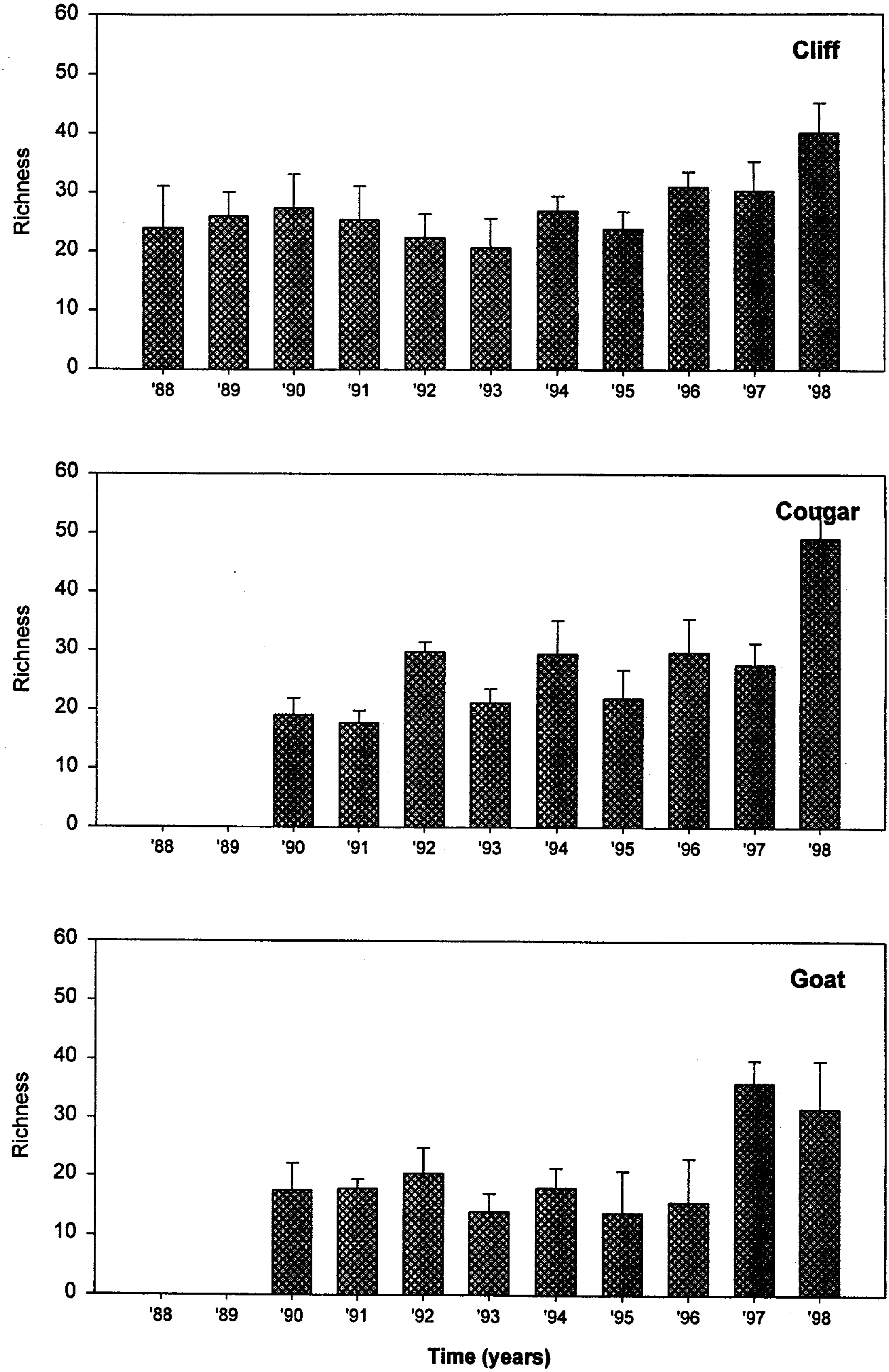

Figure 8 continued.

Cliff mean taxa richness has ranged from a low value of approximately 20 taxa in 1993 to a high of 40 taxa in 1998 (Fig. 8). Species richness was the highest in Cougar than in any other creek sampled in 1998 (Fig. 8) and was the highest mean recorded over the sample period. The taxa richness increase in Cougar Creek between 1997 and 1998 consisted of the following: three taxa of Ephemeroptera; nine Plecoptera taxa; seven Trichoptera taxa; six Diptera and two Coleoptera taxa. These new taxa represented all functional feeding groups fairly evenly. The only new taxon that was comprised one of the 15 most abundant taxa was Ephemerellidae. Goat Creek has typically displayed the lowest invertebrate diversity of any of the streams sampled. Taxa richness in Goat during 1997 was more than twice the average (15) for previous years at 36 taxa and decreased slightly to 32 taxa in 1998 (Fig. 8).

Simpson's Index, which takes into account the relative abundance of individual taxa, has shown the greatest variability among years of the community measures, although the values have been low (=high diversity) throughout the study (Fig. 9). Rush, Pioneer and Cave Creeks showed an increase in taxa richness and a decrease in Simpson's Index between 1997 and 1998 (Fig. 9). Simpson's Index in Cliff and Cougar has been variable but with consistently low values (Fig. 9). Simpson's Index decreased significantly in Goat from 1997 to 1998 to an all time low of 0.06 (Fig. 9).

The relative abundance of the 15 most common invertebrate taxa in each stream are given in Table 5. The relative abundance of the most dominant taxon ranged from 13% in Cougar Creek to 33% in Cave Creek. During 1996, Oligochaeta was the most abundant taxon in all streams except Goat Creek. In 1998, Oligochaeta was dominant only in half of the streams (Cave, Pioneer and Cliff). Other common taxa in 1998 included *Heterlimnius*, *Baetis*, Elmidae, Chironomidae, Ostracoda and Hydracarina. In general, the taxa which constitute the majority of the invertebrate community have not changed substantially over the past 2-3 years (see Royer and Minshall 1996, Royer et al. 1995).

South Fork of the Salmon River Tributaries

Only minor changes have been observed in the measured water chemistry variables in

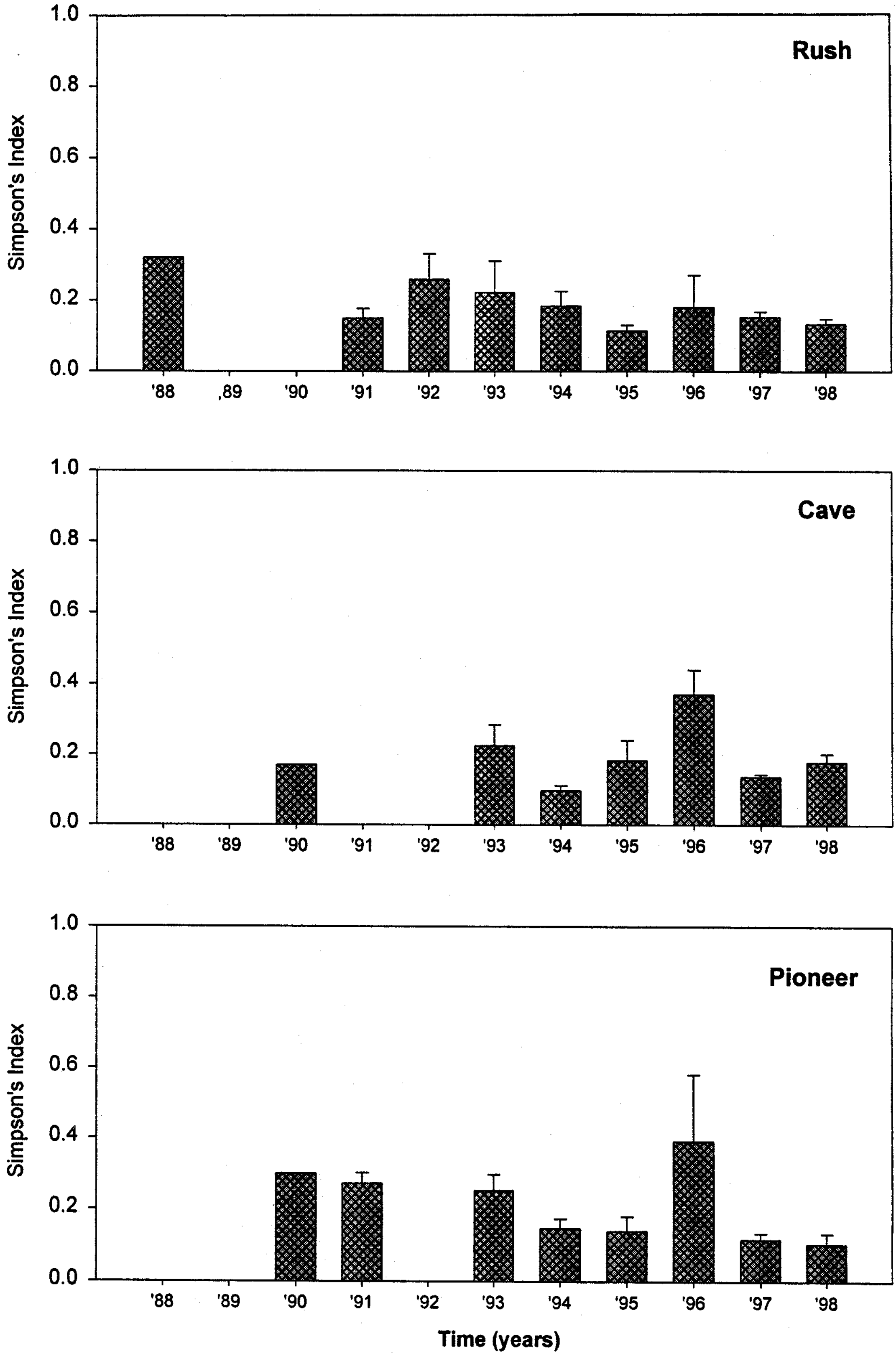

Figure 9. Mean macroinvertebrate Simpson's Index for each stream. Error bars equal +1SD from the mean, n=5.

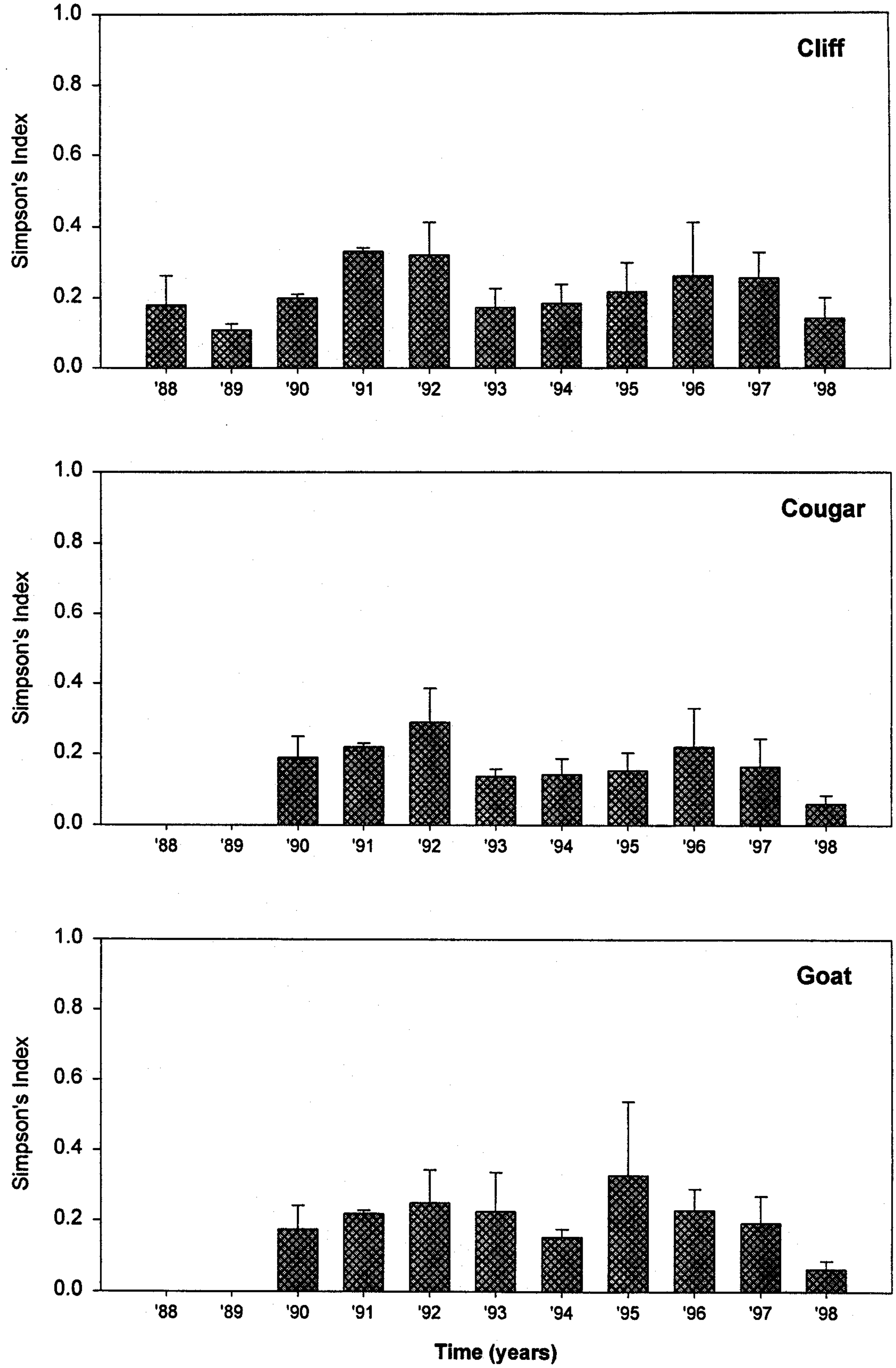

Figure 9 continued.

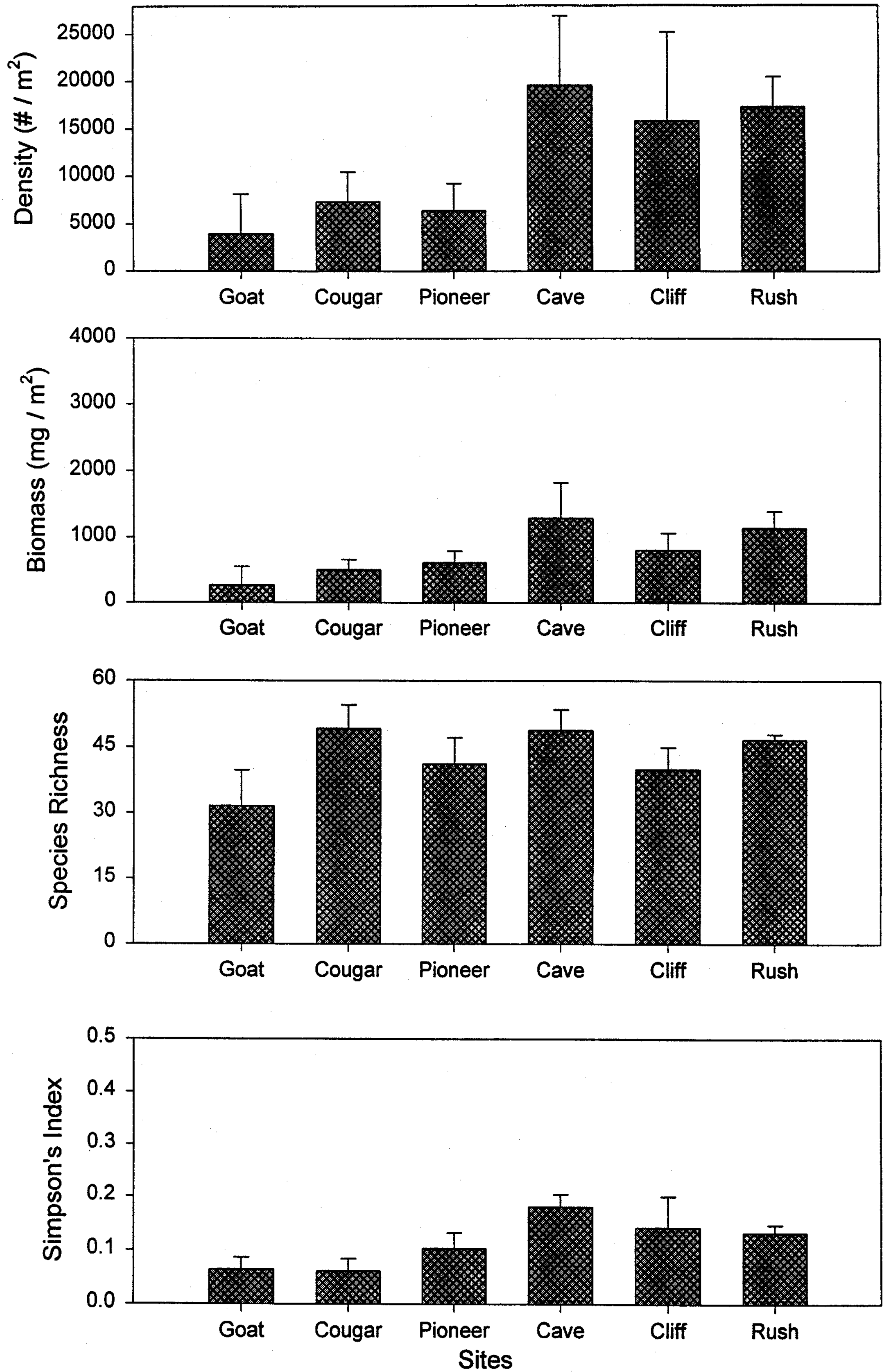

Figure 10. Mean macroinvertebrate density, biomass, taxa richness and Simpson's Index for Big Creek and its tributaries. Error bars equal +1SD from the mean, n=5.

Table 5. Relative abundances of the 15 most common macroinvertebrate taxa from each stream, 1998. SD=one standard deviation from the mean, n = 5.

Rush

	Mean	SD
Chironomidae	0.236	0.052
Baetis	0.179	0.030
Simulium	0.154	0.072
Hydracarina	0.086	0.028
Oligochaeta	0.075	0.061
Acentrella	0.061	0.021
Heptageniidae	0.040	0.013
Epeorus longimanus	0.035	0.015
Epeorus	0.022	0.007
Serratella tibialis	0.015	0.005
Deuterophlebia	0.010	0.005
Dolophilodes	0.009	0.006
Zapada	0.008	0.008
Drunella doddsi	0.006	0.003
Sweltsa	0.005	0.002

Cave

	Mean	SD
Oligochaeta	0.328	0.126
Baetis	0.235	0.078
Chironomidae	0.085	0.012
Hydracarina	0.077	0.020
Heterlimnius	0.029	0.004
Elmidae	0.027	0.010
Dolophilodes	0.020	0.019
Ostracoda	0.017	0.010
Zapada	0.016	0.010
Sweltsa	0.012	0.005
Serratella tibialis	0.011	0.004
Glossosoma	0.011	0.008
Epeorus	0.010	0.005
Simulium	0.010	0.010
Drunella doddsi	0.010	0.003

Pioneer

	Mean	SD
Oligochaeta	0.244	0.143
Ostracoda	0.113	0.019
Cinygmula	0.108	0.046
Baetis	0.087	0.041
Capniidae	0.053	0.032
Elmidae	0.046	0.028
Sweltsa	0.039	0.023
Chloroperlidae	0.036	0.033
Rhithrogena robusta	0.034	0.009
Chironomidae	0.028	0.016
Perlidae	0.021	0.009
Rhyacophila	0.016	0.006
Heterlimnius	0.016	0.006
Epeorus longimanus	0.014	0.011
Heptageniidae	0.013	0.010

Cliff

	Mean	SD
Oligochaeta	0.302	0.204
Taeniopterygidae	0.162	0.095
Rhithrogena robusta	0.096	0.039
Baetis	0.072	0.055
Drunella doddsi	0.052	0.020
Zapada	0.045	0.023
Chironomidae	0.039	0.018
Epeorus	0.032	0.020
Dolophilodes	0.031	0.028
Cinygmula	0.019	0.012
Ostracoda	0.016	0.005
Simulium	0.014	0.017
Epeorus grandis	0.013	0.014
Epeorus longimanus	0.012	0.008
Heterlimnius	0.010	0.006

Cougar

	Mean	SD
Baetis	0.131	0.022
Chironomidae	0.092	0.038
Ostracoda	0.089	0.030
Zapada	0.081	0.037
Oligochaeta	0.071	0.121
Hydracarina	0.053	0.021
Cinygmula	0.052	0.032
Taeniopterygidae	0.048	0.011
Heterlimnius	0.042	0.020
Hydropsychidae	0.041	0.012
Epeorus	0.036	0.033
Elmidae	0.033	0.016
Rhithrogena robusta	0.023	0.011
Ephemerellidae	0.018	0.010
Simulium	0.014	0.015

Goat

	Mean	SD
Chironomidae	0.149	0.073
Elmidae	0.103	0.020
Baetis	0.077	0.029
Ostracoda	0.076	0.052
Nematoda	0.060	0.041
Cleptelmis	0.056	0.057
Heterlimnius	0.054	0.033
Zapada	0.047	0.037
Oligochaeta	0.037	0.038
Hydracarina	0.036	0.007
Anagapetus	0.030	0.020
Ephemerellidae	0.028	0.021
Ceratopogonidae	0.027	0.020
Nemouridae	0.021	0.019
Malenka	0.020	0.018

Circle End, Tailholt, and Fritser Creeks (Table 6). Circle End and Tailholt have considerably more dissolved ions than does Fritser. For example, specific conductance is 5-6 fold greater and alkalinity 3-4 fold greater in Circle End and Tailholt than in Fritser. Among the sites in the salvage logging area, conductance and alkalinity varied considerably between Smith Creek and Big Flat Creek (Table 6). All of the streams sampled in previous years increased in width (usually doubled) between 1996 and 1998. Discharge decreased slightly in Tailholt and substantially in Fritser (Table 6).

All streams were affected by the 1997 spring runoff event but to varying degrees. Circle End was visibly altered by a blow out. All immediate riparian vegetation and instream debris dams were obliterated. The sediment trap located below T1 near the road was destroyed and pieces of concrete from the weir were carried to the opposite bank of the South Fork Salmon River. Substrate size and embeddedness have decreased in all three streams from 1996 to 1998, with the most reduction occurring in Circle End; 19.0 to 7.6 cm and 58 to 40%, respectively. Although Circle End and Tailholt Creeks are close in proximity, the effects were very different. Tailholt was not altered in any visible way. All riparian vegetation and within channel structures (both natural and artificial debris dams) were intact and there was not as considerable a difference in substrate characteristics between 1996 and 1998. Fritser Creek was scoured to bedrock in many places along the channel, more so than in 1996. Smith Creek was affected only in the lower two transects because of a blown out tributary that entered the stream at that point. Big Flat Creek was substantially affected due to both a road washout above the sample area and watershed scouring.

Periphyton chlorophyll *a* data for 1998 was lost due to technician error. Periphyton AFDM remained the same between 1996 and 1998 in Circle End Creek, but decreased slightly in Tailholt and substantially in Fritser Creek (Fig. 11). Periphyton AFDM was consistent between 1996 and 1998 in Smith Creek, and Big Flat Creek had a mean value comparable to Smith Creek 2.4 +/- 0.6 and 2.9 +/- 1.2, respectively. Benthic organic matter (BOM) was the same or lower in all streams from 1996 to 1998 (Fig. 12). BOM values in Circle End and Fritser Creeks decreased significantly, from approximately 165 to 17 g/m^2.

Estimates of invertebrate density and biomass in Circle End, Tailholt, and Fritser

Table 6. Discharge and chemical measures for the study streams in the S. Fork Salmon catchment.

Stream	Year	Discharge (m3/s)	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)	Conductance (uS/cm @ 20C)
Circle End	1994	0.01			186
	1995	0.01	52	68	149
	1996	0.01	40	65	129
	1998	0.01	58	69	
Tailholt	1994	0.02			143
	1995	0.06	30	56	108
	1996	0.07	28	53	76
	1998	0.05	39	48	
Fritser	1995	0.27	10	28	27
	1996	0.42	10	20	
	1998	0.14	21	28	
Smith	1996	0.12	16	44	54
	1998	0.12	25	40	
Big Flat	1996		24	57	102
	1998	0.05	41	59	

Table 7. Habitat heterogeneity measures for study streams in the South Fork Salmon catchment. SD = standard deviation, CV = coefficient of variation. R=reference, B=burned in 1994, S=logged in 1996.

		Substrate Size (cm)			Substrate Embeddedness (%)			Bankfull Width (m)		Baseflow Depth (cm)	
Stream	Year	mean (n=100)	SD	CV	mean (n=100)	SD	CV	mean (n=5)	SD	mean (n=100)	SD
Circle End (R)	1994	14.0	39.0	2.89	38.0	45.0	1.16	0.7	0.2	4.0	3.0
	1995	30.0	27.0	0.89	64.0	29.0	0.46	1.2	0.4	5.0	5.0
	1996	19.0	44.0	2.32	58.0	42.0	0.72	1.3	0.5	7.0	6.0
	1998	7.6	13.0	1.71	39.5	41.7	1.06	3.8	1.6	5.4	5.1
Tailholt (R)	1994	13.0	30.0	2.35	23.0	33.0	1.46	1.2	0.2	10.0	5.0
	1995	20.0	30.0	1.47	76.0	30.0	0.39	1.7	0.2	19.0	11.0
	1996	13.0	30.0	2.31	72.0	37.0	0.51	1.7	0.6	15.0	9.0
	1998	8.9	14.1	1.59	64.3	41.6	0.65	3.3	0.6	14.5	9.1
Fritser (B)	1995	42.0	36.0	0.84	55.0	33.0	0.60	2.8	0.4	26.0	19.0
	1996	23.0	38.0	1.65	58.0	39.0	0.67	2.4	0.9	18.0	12.0
	1998	21.5	29.6	1.38	55.5	36.2	0.65	5.6	2.0	17.9	13.4
Smith (R)	1996	13.0	11.0	0.85	51.0	39.0	0.76	3.2	0.3	17.0	9.0
	1998	19.3	26.4	1.37	45.1	28.2	0.63	5.4	2.2	15.2	11.5
Big Flat (S)	1996										
	1998	23.9	36.2	1.52	37.5	36.7	0.98	3.9	1.8	7.5	7.4

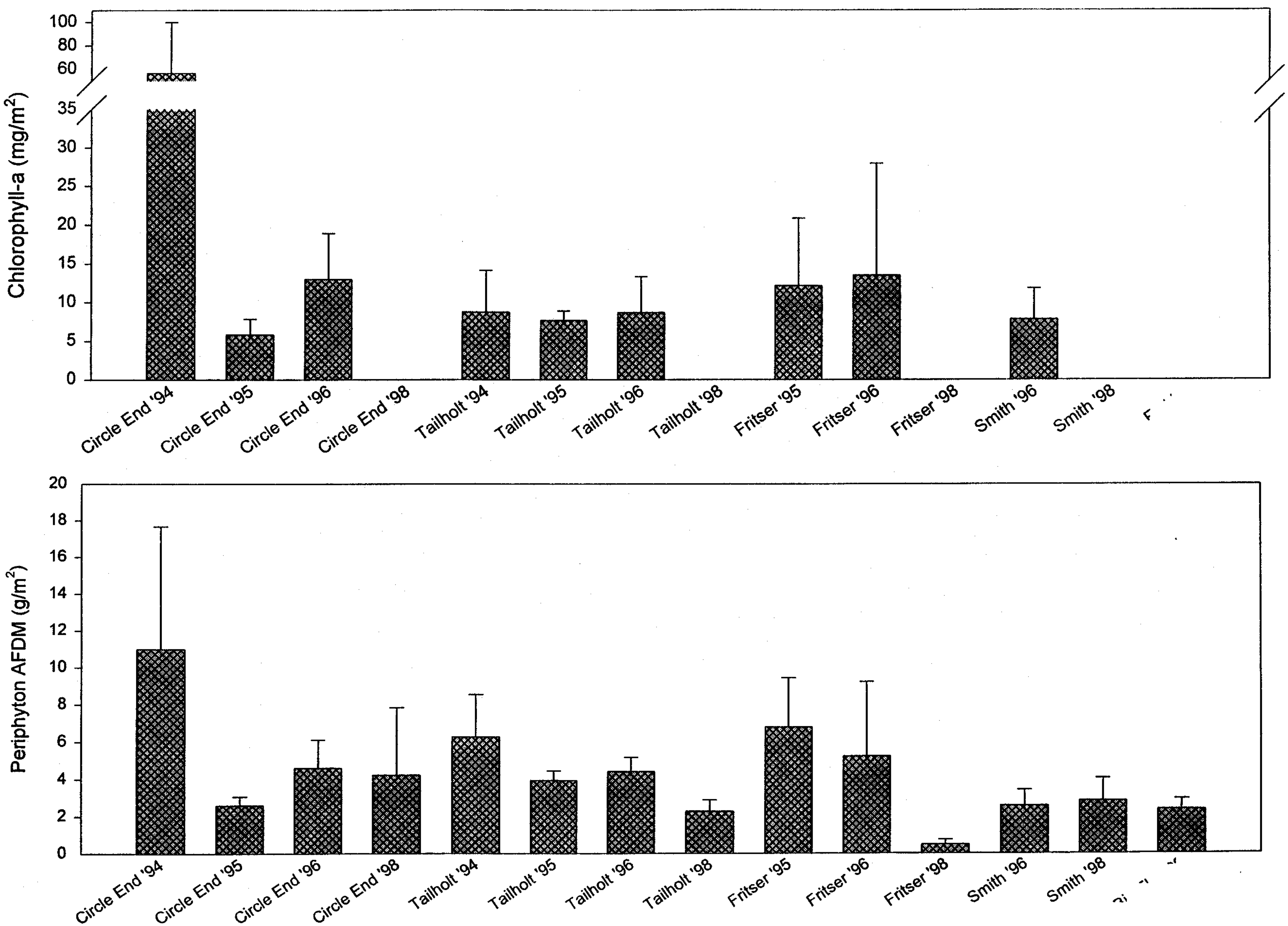

Figure 11. Mean periphyton chlorophyll *a* and ash-free dry mass (AFDM) in each stream, 1994-1998.
Error bars equal +1SD, n=5.

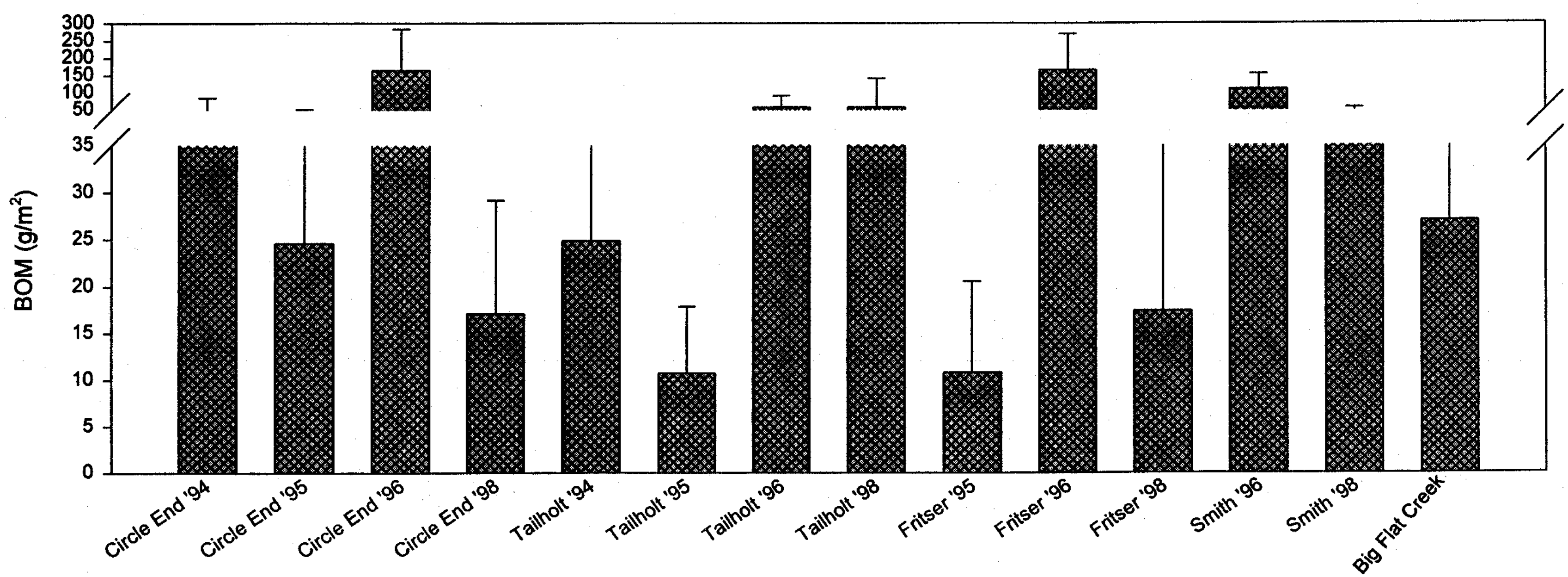

Figure 12. Mean benthic organic matter (BOM) dry mass in each stream, 1994-1998. Error bars equal +1SD from the mean, n=5.

have shown large variability within the replicate samples. This likely reflects the large amount of habitat heterogeneity in these small, steep streams. Mean density in Circle End increased from approximately 5,000 individuals/m^2 in 1996 to 13,000 individuals/m^2 in 1998 (Fig. 13). Fritser showed an opposite trend, with density declining by 75% from 1996 to 1998, while invertebrate density in Tailholt remained essentially unchanged. For all three sites, invertebrate biomass displayed the same pattern as density, except for the decrease in biomass in Tailholt (Fig. 13). Density in Smith Creek was approximately 7,000 individuals/m^2 and biomass about 1,100 mg/m^2 compared to 4,000 individuals/ m^2 and 500 mg/m^2 in Big Flat Creek.

Mean taxa richness was greatest in Smith Creek with 43 taxa (Fig. 14). Taxa richness remained the same or increased in all streams sampled except for Big Flat Creek. Taxa richness in Tailholt increased from approximately 27 taxa in 1995 and 1996 to 34 taxa in 1998. Big Flat Creek decreased in mean taxa richness from 43 to 29 taxa while its reference stream, Smith Creek, increased in mean taxa richness from 37 to 43 taxa. Simpson's Index also remained unchanged or increased in all streams sampled. Circle End values increased significantly, from 0.14 to 0.32, the highest value in the four years of sampling. All measures of Simpson's Index over the course of the study have generally been below 0.20, suggesting very diverse invertebrate communities in these streams. In particular, Smith Creek displayed an extremely diverse benthic community, with nearly 45 taxa and a value for Simpson's Index below 0.10 (Fig. 14). Of the 15 most common taxa found in each stream in 1998, Chironomidae, Oligochaeta, *Baetis*, and Elmidae, were generally the most abundant (Table 8).

DISCUSSION

Several changes were apparent in the Golden Fire streams in 1998. Mean substrate embeddedness decreased significantly in Goat and Cougar Creeks, (see Table 4) indicating the removal of accumulated fine sediments by high flows. Embeddedness has steadily decreased and the channels have progressively widened in both streams over the past five years. Also, benthic organic matter was higher in Goat and Cougar Creeks than in the unburned reference stream (Cave Creek); it was also higher than in any previous year. These changes in environmental

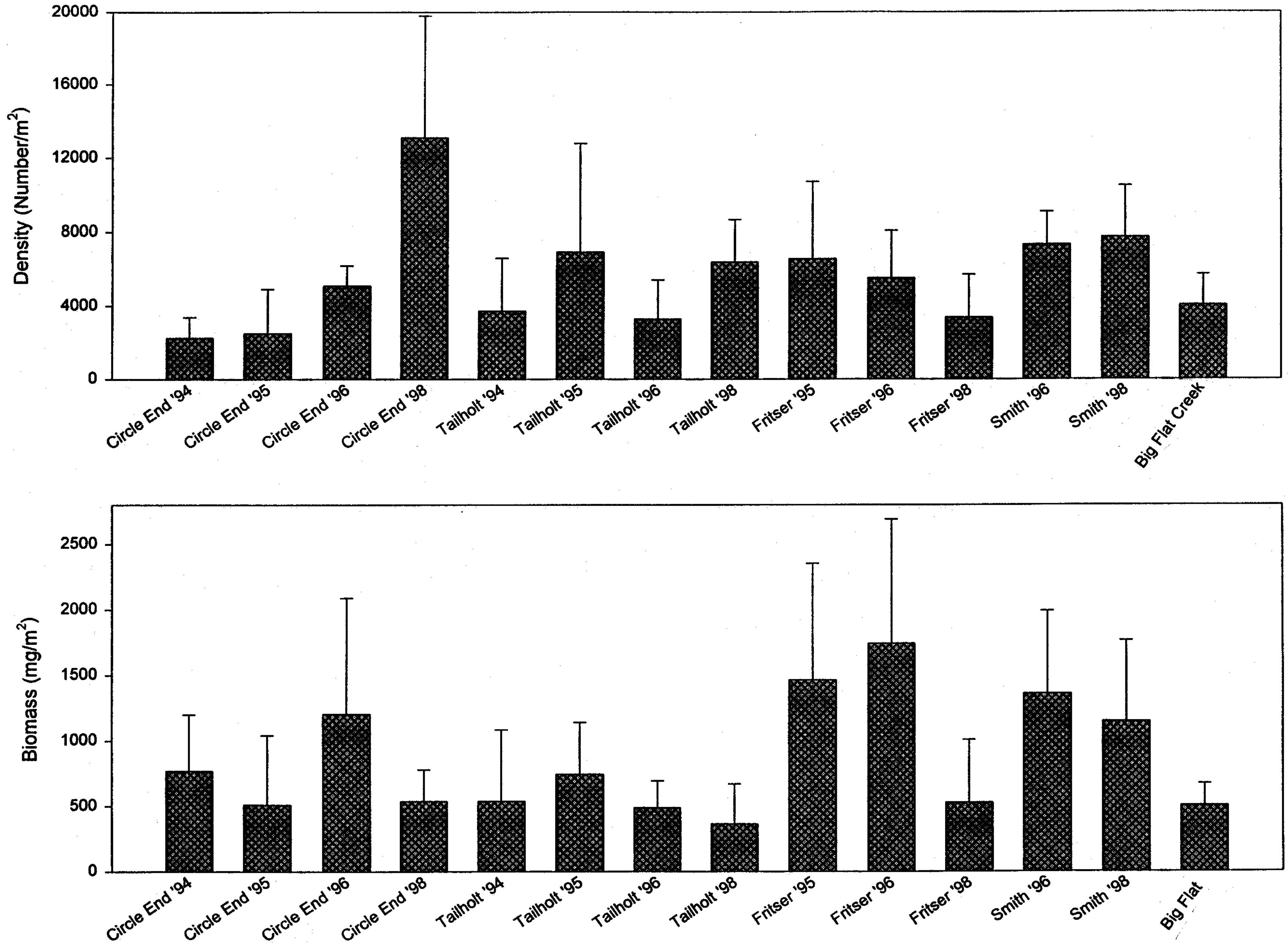

Figure 13. Mean macroinvertebrate density and biomass for each stream, 1994-1998. Error bars equal +1SD from the mean, n=5.

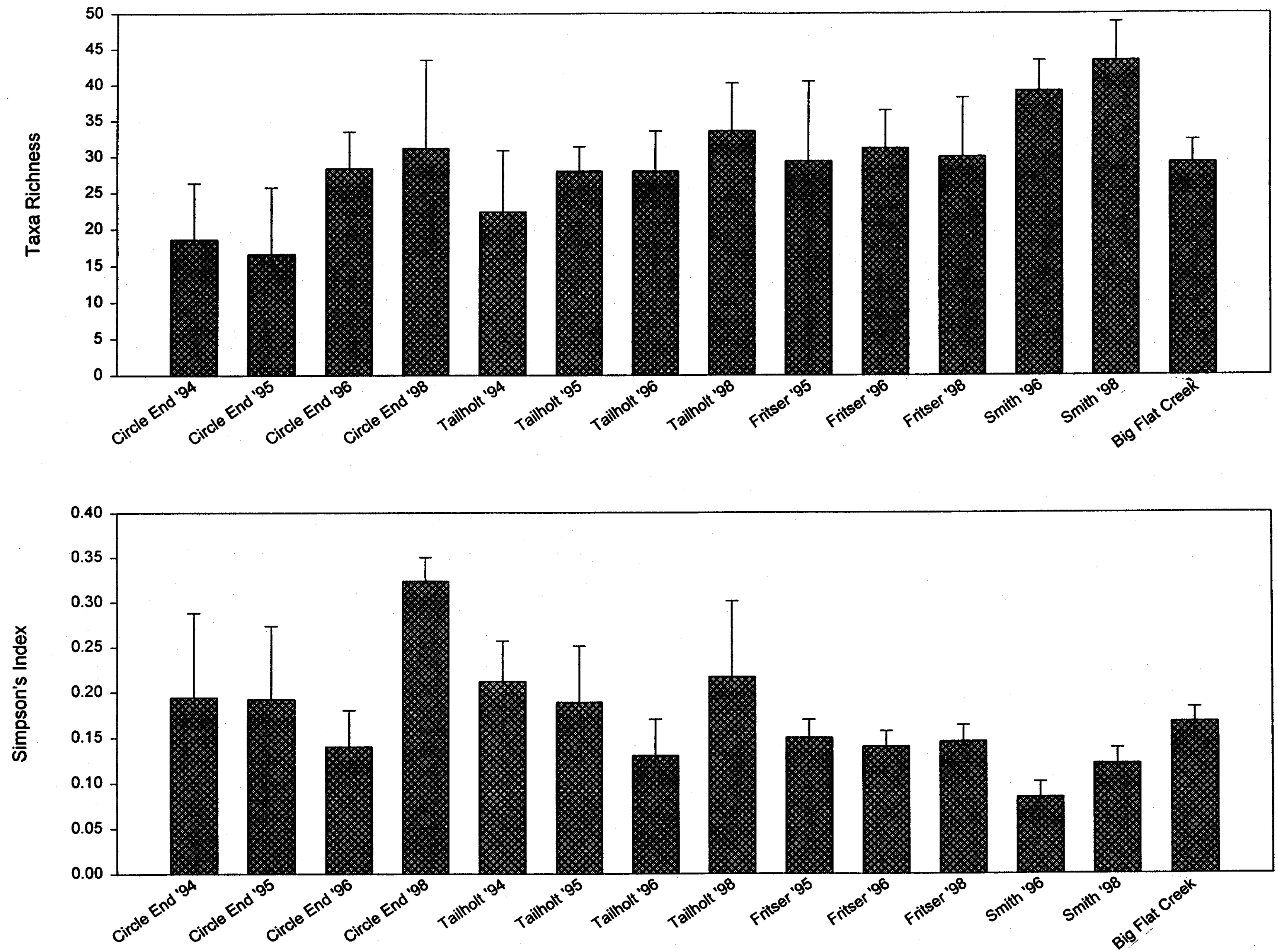

Figure 14. Mean macroinvertebrate taxa richness and Simpson's Index for each stream, 1994-1998. Error bars equal +1SD from the mean, n=5.

Table 8. Relative abundances of the 15 most common macroinvertebrate taxa from each stream, 1998. SD=one standard deviation from the mean, n = 5.

Circle End

	Mean	SD
Baetis	0.457	0.091
Chironomidae	0.333	0.125
Zapada	0.034	0.015
Capniidae	0.025	0.031
Zapada cinctipes	0.023	0.020
Oligochaeta	0.020	0.018
Simulium	0.015	0.008
Epeorus grandis	0.012	0.023
Ampumixis	0.010	0.006
Rhyacophila	0.010	0.003
Ostracoda	0.007	0.005
Dicranota	0.006	0.003
Hydropsychidae	0.005	0.002
Hydracarina	0.003	0.004
Ochrotrichia	0.003	0.002

Tailholt

	Mean	SD
Oligochaeta	0.387	0.245
Baetis	0.228	0.111
Chironomidae	0.098	0.084
Elmidae	0.049	0.031
Dolophilodes	0.026	0.050
Epeorus grandis	0.016	0.015
Nemouridae	0.015	0.009
Rhyacophila	0.015	0.009
Capniidae	0.014	0.011
Ephemerellidae	0.012	0.008
Sweltsa	0.012	0.009
Taeniopterygidae	0.010	0.011
Zapada	0.009	0.017
Ampumixis	0.008	0.008
Yoraperla brevis	0.008	0.005

Fritser

	Mean	SD
Chironomidae	0.263	0.039
Baetis	0.245	0.090
Oligochaeta	0.069	0.051
Dolophilodes	0.058	0.052
Ampumixis	0.046	0.014
Ostracoda	0.042	0.021
Ephemerellidae	0.038	0.016
Taeniopterygidae	0.031	0.013
Nematoda	0.017	0.014
Hydracarina	0.016	0.017
Zapada	0.016	0.012
Limnephilidae	0.015	0.020
Clinocera	0.014	0.010
Epeorus grandis	0.012	0.013
Rhyacophila vagrita	0.009	0.004

Smith

	Mean	SD
Baetis	0.283	0.083
Oligochaeta	0.117	0.073
Chironomidae	0.111	0.029
Drunella doddsi	0.091	0.044
Arctopsyche grandis	0.039	0.014
Ephemerellidae	0.032	0.006
Hydropsychidae	0.026	0.013
Epeorus grandis	0.025	0.011
Ampumixis	0.020	0.005
Elmidae	0.019	0.009
Zapada	0.017	0.015
Ostracoda	0.017	0.009
Simulium	0.017	0.026
Taeniopterygidae	0.017	0.013
Cinygmula	0.012	0.007

conditions were accompanied by substantial increases in taxa richness and density of the benthic macroinvertebrates. In contrast, Cliff Creek has maintained fairly stable substrate charactersitics. Macroinvertebrate density and richness however, have more than doubled the long term mean in these streams.

The Rush Point Fire streams (Pioneer and Rush Creeks) continue to show no discernable change related to burning. The results to date support out original hypothesis that the fire would have no measurable long term effects on the affected watershed and that the streams remain in an undisturbed ("reference") condition.

The Chicken Fire streams (Fritser and Big Flat Creek) showed changes relative to conditions in previous years. However, in Fritser Creek these were relatively minor compared to changes in the reference streams (Tailholt and, especially, Circle End) which showed significant decreases in riparian vegetation, woody debris, substrate size, embeddedness, and benthic organic matter in response to unusually high (100 year flood event) runoff. The environmental changes resulted in significant reductions in taxa richness of the macroinvertebrates. These changes exceeded those observed in Fritser Creek. Habitat stability in Fritser Creek may be due to the large amount of bedrock in the channel compared to the gravel/cobble substrate of Circle End, Tailholt, Smith and Big Flat Creeks. Big Flat Creek, which burned during the Chicken Fire and was salvage logged in 1997, showed a substantial reduction in species richness and community reorganization relative to its reference stream (Smith Creek). In addition to the loss of 16 species in the Ephemeroptera, Plecoptera, and Trichoptera orders, the number of taxa in the Diptera order increased by five species and individuals of the disturbance-adapted taxa, *Baetis* and Chironomidae, constituted 42% of the total numbers.

The severity a given disturbance has on the ecological conditions of a stream ecosystem can be gaged by determining if the event resulted in conditions outside the normally observed range of variability. In this regard, one goal of this research is to define the natural range of variability that occurs in wilderness streams. The abundance and diversity of aquatic macroinvertebrates provides an ecological assessment for each of the study streams. Repeated sampling of the systems allows for determination of the long-term mean and the variability around that mean for particular variables. For study streams in the Big Creek catchment, density tends to vary around a long-term mean of 4,000 to 5,000 individuals/m^2 (see Figs 4-9). Taxa richness is, in part, a function of stream size (Minshall et al. 1985), and this can be seen in the long-term mean taxa richness for Rush Creek versus Cliff Creek and Cougar Creek. Rush, the largest stream, typically has about 35 taxa, whereas Cliff and Cougar (both smaller than Rush) have about 28 taxa. This difference is not large, but it is consistent over 7-9 years of study. Long-term trends such as these provide important assessment tools for resource managers.

The relationship between stream size and species richness also was observed in the South Fork Salmon River tributaries. Smith Creek, the largest stream sampled along the SF Salmon contained nearly 45 taxa and the smaller streams, Circle End and Big Flat Creeks, contained approximately 27 taxa. In long term trends, taxa richness appears to be similar between the Big Creek and SF Salmon sites, as well as other sites in the Frank Church Wilderness (e.g. Richards and Minshall 1992). However, taxa richness increased more in the Big Creek sites between 1996 and 1998 compared to the SF Salmon sites. This increase may be due to precipitation differences between the two areas. In addition, the SF Salmon sites have a slightly different aspect than the Big Creek sites. The SF Salmon sites were much more affected by the 1997 runoff than the Big Creek sites.

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